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DISCOVERY

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TWELFTH BIRTHDAY NUMBER

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Notes of the Month.

WITH this issue we celebrate our twelfth birthday, and we thus commemorate a period which has been notable for advance in every branch of knowledge. A glance at the pages of *Discovery* will afford some indication of the progress which has marked the post-war years. It was the intention of the founders that the journal should not be limited to an account of purely scientific discoveries, and if during the past twelve years we have been able to record for the first time scientific discoveries of momentous importance, we have also endeavoured to discuss new aspects of other subjects, including history and literature. We are confirmed in the belief that *Discovery* has fulfilled the founders' purpose by the messages of congratulation received from many eminent readers, among whom may be mentioned Sir Oliver Lodge, Sir J. J. Thomson and Sir Frederic Kenyon.

* * * * *

It is appropriate that there should be an element of retrospection in this number, and on another page Sir J. Arthur Thomson contributes a review of progress in biology since the war. In this, as in other branches of scientific inquiry, advance is in some cases abrupt while in others it is a gradual process which Sir Arthur likens to the dawn. Such a process is the investigation of nervous impulses—the transmission of "messages" from one part of the body to another at a velocity of four hundred feet per second. An important branch of this work, in which considerable progress has recently been made, is the study of "conditioned reflexes." A familiar instance of the conditioned reflex is the fact that a dog's mouth waters when it is shown food; and it is well known that if the animal learns to associate the blowing of a whistle with the prospect of a meal, its mouth will water whenever the whistle is blown even if there is no food. An important outcome of experiments of this kind is that they have enabled the strength of the reflex to be measured by the amount of saliva secreted. This study has thrown valuable new light on many hitherto inexplicable phases in human and animal behaviour.

* * * * *

Twelve new species are included in a valuable collection of West African birds just purchased by the British Museum. The collection numbers over six hundred specimens, and has been made in Sierra Leone during the past year by Mr. G. L. Bates. He is the first naturalist to visit this region, and some of his most important discoveries were made on Mount Nimba, one of the highest peaks in West Africa. Mr. D. A. Bannerman, of the British Museum of Natural History, will contribute an illustrated account of the new finds to the next issue of *Discovery*. The author, who has long recognized the inadequacy of our knowledge of West African birds, was largely instrumental in persuading Mr. Bates to visit Sierra Leone and helped to organize the expedition. Lack of communications and insufficient knowledge of tropical diseases have not until recently permitted systematic exploration of the African continent. Although the Sierra Leone expedition has not yielded such remarkable results as the collector's recent exploration in the Cameroon-Nigerian Highlands, the new discoveries are regarded as an important contribution to ornithological knowledge.

* * * * *

Another interesting feature of the May number will be an article by Mr. F. W. H. Migeod, leader of an expedition which has just returned from East Africa, in which the author describes the discovery of the remains of dinosaurs in Tanganyika. Among these important finds were the fragments of a creature closely resembling a gigantic giraffe which is thought

to have been about forty-five feet high. The tail of this specimen was probably twenty feet long, while its total length from nose to tail is presumed to have been over seventy feet. The skull, usually the most interesting part of the creature, was unfortunately missing. Mr. Migeod points out that the skull of the dinosaur was surprisingly delicate and therefore quickly disintegrated ; rarely are fragments unearthed. Another interesting find was part of the skull of a sauropod. The new discoveries are likely to lead to a more definite estimate of the age of the dinosaur, which is at present thought to have been about sixty million years ago.

* * * * *

Knowledge gained from scientific research plays a growing part in the development of modern industry. In times of industrial depression, however, firms which maintain research laboratories are tempted to reduce expenditure on what is not at first sight an immediately productive branch of industrial organization. But it should be clear that at such times research can be most valuable, and a plea for a wider acknowledgment of the help which science can give in the revival of trade is contained in the latest report of the Department of Scientific and Industrial Research. The making of new discoveries is not the only way in which science can be of service, and while the report contains nothing of a spectacular nature, it shows how the daily application of existing scientific knowledge has yielded good results in increased efficiency of production. One important new development is announced, namely, a scheme for the establishment of a national experimental station for testing locomotives. The station will be equipped with the latest testing apparatus, and a dynamometer car will be provided for use on the track.

* * * * *

Widespread interest has been aroused by the preparations for Sir Hubert Wilkins' submarine expedition to the North Pole. As previously announced in *Discovery*, the voyage is to be made in the American submarine *Nautilus*, which has been reconditioned at a cost of £100,000. It is proposed to travel on the surface through open sea, submerging when ice is met with. According to the latest reports in the *News-Chronicle*, the submarine has been equipped with runners to enable it to glide under the ice, while a guiding arm acts as an additional precaution against collisions. The conning tower is fitted with drills which are capable of penetrating sixty feet of ice, and there is an arrangement of tubes through which fresh air will be drawn into the submarine while it is under the ice. It will be possible to remain submerged for about a year at a time. When Sir Hubert visited us last summer, he discussed the interesting possibility of broadcasting an account of progress from the submarine and of making a continuous talking picture. As we go to Press we learn that *Nautilus* has left Camden Shipyard, where the reconstruction took place, and lies in Brooklyn Navy Yard, where the explorer is awaiting a favourable opportunity to carry out tests.

* * * * *

Dr. Ferdinand Ringer, an Austrian scientist, has invented a " match " which is capable of being lighted six hundred times. The device is no larger than an ordinary match, but is composed of special chemicals. When the match is struck in the normal way gases are released which feed the flame, and on reaching a certain temperature, the flame is extinguished by a release of nitrogen gas. This process may be repeated six hundred times, and the flame lasts long enough to enable a cigarette to be lighted. A larger match, intended for domestic use, is capable of being used two thousand times. The material of which the device is composed is non-poisonous, and if a lighted match is dropped contact with the ground extinguishes the flame. The invention is not yet in practical use, but Swedish match interests are reported to be in negotiation with the inventor for the purchase of the patent.

* * * * *

A striking instance of the value of aerial photography as an aid to archaeology is the fact that four temporary camps along Hadrian's Wall are revealed for the first time in a survey just completed by the Royal Air Force. A valuable result of the survey is the new light which is thrown on a large civil settlement close to the fort at Borcovicus. While excavations failed to disclose the actual size of the settlement, a photograph of the site from the air not only reveals its true extent but contains details which do not appear in previous plans. These discoveries are of considerable public interest, for the site was recently presented to the nation and the fort has already proved rich in Roman remains. The aerial photographs will be of great assistance in excavating the civil settlement.

* * * * *

The Norvegia Expedition is continuing its work of the last three years in the Antarctic, and now reports the discovery of new land about five hundred miles south-west of Enderby Land. The new coast is in one of the least known regions of the Antarctic and was found in the course of a seaplane flight. While as land it is of no practical use, the new discovery fills a notable gap in the outline of the South Polar Continent.

Twelve Years' Progress in Biology

By Professor Sir J. Arthur Thomson, M.A., LL.D.

During the period which this number of DISCOVERY *commemorates there has been notable progress in every branch of biology. Some outstanding advances are here reviewed by Sir Arthur Thomson, who shows how the post-war period has been marked by a growing application of biological research to everyday life.*

In estimating the scientific progress made during a stretch of years—such as those since the War—one must give the period the credit of discoveries which came into prominence during that time, although one knows that they are but the published outcome of what began long before. In the same way one gives May the credit for flowers that began to open in April. In the opposite direction, not being prophetic, one labours under the disadvantage of almost certainly failing to appreciate inconspicuous steps which will mean much in days to come. The history of science shows that many buds of new knowledge have slowly developed for a long time before they opened; and the same must be true to-day.

The chronicler, now seeking to disarm criticism before he begins his ambitious task, has also to face the difficulty of distinguishing between precursors, initiators, continuators and expositors—all with their distinct and legitimate function. Thus Quetelet was a precursor of statistical methods, Galton an initiator, Pearson a continuator, and—no one likes to be called an expositor! What I wish to suggest is that no one can appreciate the progress of science through a particular stretch of years in the precise fashion of an accountant who tells the story of a particular bank, say, during the last decade. For science is a subtle thing, growing and developing like an organism; and we have to do not with one mustard seed, but with many.

An Important Step.

A step that seems to me of high importance—though some colleagues dissent—is the work of Professor Baly and his collaborators in synthesizing simple carbon-compounds by the action of light on water and carbon dioxide. Using light-rays of very short wave-length from a mercury vapour lamp, Baly was able to effect the synthesis of formaldehyde and then of sugars, thus mimicking what occurs in every sunned green leaf. Moreover, he was able to get the same results by using sunlight in the presence of a metallic catalyst. Going further, Baly was able to induce formaldehyde to combine with nitrites, thus approaching the nitrogenous carbon-compounds which are characteristic of protoplasm. As ammonium nitrite might be formed in primeval days by electric discharges in the air, just as man makes it to-day in synthesizing fertilizers, and might be carried down by the thunder shower into a sunlit pool, there might come about in natural conditions, apart from life, a synthesis not only of carbohydrates but of nitrogenous carbon-compounds, approaching the amino-acids, which have been called the building stones of life.

Long Standing Problems.

Confirmation and extension of Baly's researches are, of course, eagerly looked for; but it seems as if another step had been taken towards the solution of the long-standing problems of photo-synthesis and of the primeval origin of the living from the not-living. In regard to the more remote problem, it may be further noted that it has lost some of its insoluble appearance in the light of what is now known (*a*) of inorganic catalysts and organic enzymes, (*b*) of the properties of colloids, (*c*) of the chemist's synthetic creations, and (*d*) of extremely simple organisms like those of the filterable viruses.

The fourth edition of Bayliss's influential book on "The Nature of Enzyme Action" was published in 1919; and to compare with it J. B. S. Haldane's recent "Enzymes" (1930) is to realize something of the progress that has been made in the study of fermentative processes between these dates. Not only is the list of known enzymes greatly increased, but our knowledge of the subtlety of their action has been deepened. In so many pies have enzymes a finger that biology cannot even be "outlined" without bowing at every turn to catalytic magic. Haldane defines an enzyme as "a soluble, colloidal, organic catalyst, produced by a living organism"; and he adds humorously that while the definition will be out of date when an enzyme is prepared synthetically, his book will be out of date long before then. For this is a department of bio-chemistry in which progressive movement is most marked.

Everyone knows that the rapidity and untiring

intensity, the coolness and compactness of vital processes cannot be thought of apart from enzymes, but it is not easy for the busy botanist or zoologist to get more than glimpses of the knowledge that is being gained of the part that these enzymes play throughout the world of life—from green leaf to sprouting seed, from contracting muscle to digesting stomach, in respiration and in excretion, from pigment-forming to luminescence, in anabolism and in katabolism, perhaps even in the fertilization of the egg. The business of life cannot be conducted without fermentation.

The Study of Enzymes.

Bayliss was a champion of the view, now held unanimously, that enzymes are to be included within the rubric of catalysts, such as the porous platinum on whose surfaces oxygen and hydrogen are brought into such close quarters that they unite. Similarly, according to Bayliss, the colloidal catalysts that we call enzymes afford, on their suspended particles or droplets, multitudinous surfaces on which the substrate (or material acted on) undergoes adsorption and consequent change. But during the decade we are concerned with, there has been a movement towards the view, expressed in Haldane's book, that the substrate actually combines in a transitional way with the enzyme. While we do not yet know what there precisely is in the structure of an enzyme that enables it to act as it does, we seem to be progressing towards that knowledge. In any case, it is now evident that many changes which were regarded in the past as distinctively vital are now referable to the action of enzymes—which are, however, not known as yet to be produced except by living cells.

The discovery of glutathione by Sir Frederick Gowland Hopkins about 1928 is a milestone in the history of biology, though one might perhaps be a very sound and learned biologist without having ever heard the substance's not very luminous name. Few of us can play on more than a few octaves on life's long gamut. Glutathione is a linkage of two amino-acids—glutamic acid and cystein—and although it is excluded from the enzymes proper by being crystalloidal (a white amorphous powder when purified) it exerts a very important catalytic action within the living cell. It acts as an intermediary between the oxidizable material and the molecular oxygen in the cell; or, to put it in another way, it mobilizes the hydrogen of the tissue-materials and carries it to the oxygen.

As most of the energy of the living body is due to oxidations in the cells, the importance of glutathione, which is of general occurrence, is obviously fundamental. And since it is only an intermediary or vehicle, a little can go a long way, just as is true of an enzyme proper. Here also should be included Keilin's discovery of cytochromes, about 1925. These are colourless cell-pigments of very widespread distribution in plants as well as in animals, and they contain the " hæm " nucleus which occurs, linked to a protein, in the hæmoglobin of red blood. Like hæmoglobin the cytochromes are carriers of oxygen, but their function is not for long distances, being restricted to the narrow confines of the cell-laboratory. They are concerned with the intra-cellular control of oxygen and are therefore of fundamental biological importance.

For many decades physiologists have tried to discover how a muscle contracts, but the *complete* solution of the problem is still for the future. It cannot be denied, however, that great progress has been made during the period on which we are focussing attention, especially through the studies of Meyerhof, Embden and A. V. Hill. Modern advance in this field began with the investigations of Walter Morley Fletcher and Frederick Gowland Hopkins, who showed that when a nerve-message " orders " a muscle to contract, there is a production of lactic acid from some previous substance (the carbohydrate glycogen) in the living threads or fibres that make up muscle or flesh, and that the lactic acid by its mere presence causes the fibres to contract.

This is a physical surface phenomenon, not in itself involving any oxidation or combustion, as used to be supposed. The physical change might be compared with the uncoiling of a released spring, except that the muscle spring becomes shorter not longer when set free; but one can never forget Sir Charles Sherrington's remark that " the engineer would find it difficult to make a motive machine out of white of egg, some dissolved salts and thin membrane," which is practically what Nature, so to speak, has achieved in evolving the quickly contracting, hard-working muscle.

How Muscles Work.

This at any rate is now clear: it is in the non-oxidative first chapter that the muscular work is done; and Meyerhof seems to have made it certain that the source or precursor of the lactic acid is the " animal starch " or glycogen, which Claude Bernard discovered long ago in the liver. Between the glycogen and the lactic acid there is some intermediary, probably of the nature of sugar-phosphate (hexose phosphate). The lactic acid that is formed is changed into potassium lactate by the alkalinity of the

proteins of the muscle. And thus ends chapter one.

But if the muscle is to recover and do more work, the lactic acid (now a lactate) has to be removed, and this is what happens in the oxidative or recovery chapter. The lactate is changed back into lactic acid, and this into the intermediary, and this into glycogen again. The energy for the process is obtained from the oxidation of part of the glycogen, the supply of oxygen coming ultimately from the outside world via the circulation. We see, then, that in muscle contraction there is a working phase without oxygen, and then a recovery phase with oxygen; and the progress during our selected period has been, in general terms, that the ledger of changes in material and in energy has become ever so much clearer.

Nervous Impulses.

In some cases a step of progress is marked by more or less abruptness, as in the discovery of radio-activity, or vitamins, or hormones, or Mendelian Inheritance—buried though it was from 1865 to 1900; but in other cases a problem is investigated for many a year without more than a very gradual increase of light. Some solutions come like flashes of lightning, but most are like the dawn. In biological language, some are mutations, others are like variations which gather strength, through a long lineage, by minute increments. Of the second type is the progress towards a better understanding of what is meant by a nervous impulse—the conduction of an excitation from one part of the body to another. Even among the Protozoa there are fibrils which seem to be specialized for conduction, just as others are specialized for contraction, like the familiar filament up the centre of the stalk of the Bell-Animalcule.

What is the nature of this nervous thrill, which has a velocity of about four hundred feet per second in mammals, a quarter of that in a frog, and much less in many an invertebrate? It has often been compared with an electrical current, and it is certainly associated with electrical changes; but the probability is that the electrical changes are concomitants rather than causes. The impulses, as indicated above, vary in velocity; and this is true within the same animal, one of the factors being the diameter of the nerve-fibre; but the researches of Keith Lucas, Adrian and others have shown that the impulses in a single normal fibre are of constant strength. That is to say, if a fibre carries a message at all, it carries it at full power. This is known as the "all or none" law, and it must be kept in mind in trying to understand what happens when a message travels along a nerve—one of the most familiar of vital phenomena.

Keith Lucas has compared a nerve impulse with the advance of an explosion along a train of gunpowder, but the comparison leaves us wondering how the nerve recovers itself so quickly and is ready to carry another message. To another objection—that there is no evidence of oxidation—an answer has been forthcoming during our decade, for Professor G. H. Parker has demonstrated that the minute amount of carbon dioxide produced during rest is slightly increased when the nerve is activated. Tashiro has shared in this advance by his invention and application of a very delicate "biometer," which can detect such a minimal quantity as 0.0001 of a milligram of carbon dioxide!

But a correlated achievement of the period under discussion is the evidence recently brought forward by Professor A. V. Hill and his collaborators, that a minute quantity of heat is generated in the transmission of an impulse. The amount of heat produced in one second's activity was about enough to raise the temperature of the nerve by one ten-thousandth part of a degree. If, as seems likely, this nerve heat is produced by something analogous to a combustion process, then it should correspond to the increment in the output of carbon dioxide; and this is the case. Thus science closes in on its problems, without haste, but without rest.

Coming in part into the period after the War are the impressive experiments by which Sir Jagadis Chunder Bose has demonstrated the exquisite sensitiveness of plants. Everyone knows the aphorism of Linnæus: "Lapides crescunt; vegetabilia crescunt et vivunt; animalia crescunt et vivunt et *sentiunt*!"; but if "*sentiunt*" means being sensitive to and responding to stimulus, the aphorism is very far from being true to the facts; and we owe to Bose some of the most convincing demonstrations of the delicate irritability possessed by the apparently somnolent plants. We may not agree with Bose's deliberate habit of transferring terms from animal to plant physiology, but he has shown himself a master of experimental methods, and he has done great service in deepening the biologist's appreciation of the sensitiveness of common plants.

The Sensitive Plant.

A wayside tree may answer back to a passing cloud; and the Sensitive Plant *par excellence* exhibits responses which present a close, though perhaps illusory, resemblance to reflexes in animals. We should be inclined to reckon Bose's "Nervous Mechanism in Plants" (1926) as one of the notable books of our period—what the Germans call *bahnbrechend*; but an illustration of the need for caution may be found

in the researches of Ricca and of Snow, which interpret the conduction of stimulus in the Sensitive Plant in terms of the diffusion of hormones, and not in terms of nerve impulse in the sense in which the term is used in animal biology.

Conditioned Reflexes.

Thinking of nerve impulses leads us naturally to Pavlov's researches on "conditioned reflexes," and although these began long before the War, they were not generally available until the Russian's books and papers were translated; and the dates of the translations are within our circumscribed period. In an ordinary "unconditioned reflex" a stimulus affects the ending of a sensory nerve; an impulse travels to associative nerve-cells in a nerve-centre, which in back-boned animals is usually in the spinal cord; the message excites adjacent motor nerve-cells and is transmitted down a motor nerve to muscles which move, or, it may be, to glands which secrete. Thus a smart tap below the joint of our leg when it is swinging freely over the other at the knee, is followed by a jerk which sends our dangling foot up into the air. The brain is aware of what happens in this case, but the brain is not needed for this familiar reflex action.

A pre-arranged or inborn linkage of sensory, associative, and motor spinal neurons is sufficient in itself, with, of course, the muscle-fibres, to give effect to the motor commands. Such reflexes are among the commonest occurrences in man and beast, as when we draw away our finger from a hot cinder or our foot from a sharp tack, or when the earthworm jerks itself back into its hole at the approach of a blackbird, or when a nestling opens its mouth at the touch of food in its mother's bill. It is characteristic of unconditioned reflexes that they are inborn, that they do not require to be learned, that they are shared by all members of the species, and that they are often quite independent of the brain for their performance. They are involuntary, yet they can be in some cases voluntarily inhibited, as when the fugitive in concealment suppresses a betraying cough.

What is a "conditioned reflex"? If a dog is shown a piece of flesh its mouth waters. If a whistle is always sounded when the flesh is shown to the dog, an association (in the old-fashioned terminology) is gradually formed between the sound and the prospect of a meal. This linkage may become so strong that the dog's mouth will water when the whistle is sounded, although there is no flesh in sight. The flow of saliva in the dog's mouth illustrates a conditioned reflex, and this particular experiment, much elaborated by Pavlov, has the advantage that the strength of the reflex action can be measured by the amount of saliva secreted. Measurement goes to the core of science.

The dog learns to associate a particular sound (or it may be the sight of a printed card) with a meal, till the sound works as well as the flesh itself in inducing a flow of saliva. A message from a sense organ passes to a sensory centre in the brain, and thence to a motor centre, whence an order passes to the salivary gland. This new kind of reflex, engrained by particular conditions of individual experience, was called by Pavlov a conditioned reflex, in contrast to an inborn unconditioned reflex which is present from the first and arises more or less apart from any particular conditions. The conditioned reflexes are usually less powerful than the unconditioned, and slower, but the essential difference is the interpolation of the novel cerebral switching of nerve-impulses from a sensory to a motor centre.

Why should this study be so very important? Because it leads to a clearer understanding of great stretches of behaviour in man and beast. Suppose someone who knew nothing of the dog's experiences saw its mouth watering when the whistle sounded (and it might be a Galton whistle, which is too high-pitched to be audible to man), would he not infer that this strange response was part of the dog's inborn make-up? Similarly, because we do not know enough about early experiences, we are apt to regard certain human and animal responses as automatic, or instinctive, or even clever, whereas they are really acquired conditioned reflexes, often, of course, far subtler than the simple case of the dog and the whistle. The conditioned reflex is a formative unit in the development of behaviour; and I have emphasized its recent study, though only touching the fringe of the subject, because the idea has become a new organon in bio-psychology.

Many Advances.

It seemed more useful to select a few steps, explaining their importance, than to attempt a more comprehensive survey, which within limits of space would have become too like a catalogue. Yet in closing, I am aware that I have not done more than emphasize a few advances which appeared to be of peculiar significance. The fact is that biology is like a tree with a growing point at the end of every branch.

What pictures crowd into the mind when we say "Recent Advances." How indescribably quaint are Dr. Tate Regan's parasitic pigmy males among the ceratoid angler-fishes, queer little fellows fastened

on to some protuberance on the female, with their oral tissues coalescing with her tissues, so that they become one flesh.

Knowledge of Symbiosis.

How striking is the increased knowledge of symbiosis, or mutually beneficial internal partnership, which is of much more frequent occurrence than anyone had imagined. It may be between plant and plant, as in the case of the partner fungi of orchids and heathers; or it may be between plant and animal, as is illustrated by the yeasts in the food canal of many insects, enabling them to thrive on dry-as-dust food; or it may be between animal and animal, as exemplified by the beautiful Infusorians that live in the food canal of wood-eating worker termites, enabling them to flourish even on filter-paper for every meal.

How surprising are those cases of animal luminescence, as in some cuttlefishes, where the light appears to be produced by bacteria localized in little tissue-nests, whereas in the better known cases of fire-flies, piddocks, and small crustaceans, the older theory of Dubois and Newton Harvey seems still to hold, that a fermenting luciferase provokes the production of light by oxidizing a protein-like luciferin.

The study of animal behaviour, having begun to develop along experimental lines and on a basis of circumstantially critical observation, has continued to make great progress, and better examples could not be mentioned than Elliot Howard's studies of "territories" among birds or the courtship of yellow-hammers and their relatives. Corresponding in a way to the Adlerian Individual Psychology are various open-minded objective studies of individual animals, such as Professor Ritter's study of the California woodpecker which has developed the interesting and profitable habit of boring hundreds of holes in tree-stems and inserting well-fitting acorns, which serve as a store during hard times. The pioneering experiments on "homing," made by Watson and Lashley on the terns of the Tortugas, have been followed up for other types by Rabaud, G. H. Parker, and others; and the whole subject of orientation has begun to be scientifically discussable. Here may be mentioned A. L. Thomson's very scientific and well-documented analysis of bird-migration. Another pioneering line of great promise is indicated by Alverdes's book on "Animal Sociology," and by Wheeler's suggestive studies of social insects.

Very noteworthy advance has been made in verifying the theory which regards the chromosomes as the vehicles of the initiatives or factors of many at least of the hereditary characters; and the work of T. H. Morgan and his school stands out pre-eminently. It is interesting to find that a topography of the chromosomes is in some cases possible, the "factors" or "genes" seeming to lie in a definite linear order along the chromosome; yet this is but one of the minor results of the recent study of the physical basis of heredity. How striking, for instance, is H. J. Muller's evidence that X-rays can induce mutations of genes; or the proof given by Ruggles Gates, Hirst, and others that new departures or mutations may be associated with a multiplication of chromosomes (polyploidy), and that a series of related species, both among plants and animals, may show an arithmetical progression in the number of their chromosomes, such as 7, 14, 28, and so forth, in different species of rose.

In no direction during our selected period has progress been more marked than in the field of experimental embryology. This may be illustrated by reference to Child's concept of "axial gradients" in which, along a particular line or area, there is a regular curve in the intensity of protoplasmic activity; or Spemann's concept of "organizers" where a particular region, such as the dorsal lip of the blastopore of a frog's embryo, acts in an extraordinary way as an originator of differentiation in adjacent tissue—even when transplanted to an irrelevant position in some other, but related type, as from frog embryo to newt's. I dare not begin to deal with recent progress in morphology and taxonomy, palæontology and pedigree deciphering, comparative embryology and the factors operative in organic evolution, not to speak of genetics, cytology, protozoology, bacteriology, and so forth; I can only say that during the post-war period in the history of *Discovery* there has been notable progress on all these lines, as a return to its many-sided articles will clearly show.

Application to Everyday Life.

But there are two concluding remarks which I cannot refrain from submitting, even though limits of space have been outrun. The first is that there seems to be a growing desire to cease opposing as antithetic what are really complementary views. Thus an eirenicon or rather a higher synthesis is being found between mechanistic and vitalistic formulations, between behaviourist and psycho-biotic ecology, between neo-Lamarckism and neo-Darwinism, and similarly with other controversies. The second point is that the post-war period has been marked by a growing discernment of the practical value—indeed indispensability—of biology as a guide in the control and amelioration of human life.

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A Royal Necropolis in the Balkans.

By Stanley Casson, M.A.

Twelve years ago a series of tombs were accidentally discovered in a remote region of the Balkans and proved to contain the richest Greek remains ever found so far north. A new grave has now been found and the nature of its contents confirms the belief that the cemetery is a royal necropolis.

THE poverty of Balkan life has rarely allowed the same scale of magnificence and splendour either in the objects of daily use or in the trappings of the grave as is found in Egypt, Syria and Mesopotamia. Except for the splendid Mycenaean burials of the Shaft Graves at Mycenae and for the recently opened tomb at Mideia, Mycenae's neighbour, Greece and Balkan lands have little to show to rival the magnificence of the East. But in the very heart of the wildest part of the north Balkans there has been discovered a cemetery which must rank as the richest and the most interesting from all points of view that has ever been revealed north of the Gulf of Corinth.

The history of its discovery is curious. In May, 1918, Bulgarian troops engaged in road-making in the region just north of Lake Ochrida, which lies almost midway between the Aegean and the Adriatic, came upon a series of tombs of well-made stone slabs. Five in all were opened at this time, but later investigations by Professor Schkorpil of Varna revealed two more. The seven graves contained a wealth of ornaments and weapons of all kinds, mainly of Greek manufacture, of the archaic period, and the number of gold and silver objects was remarkable. The contents of the graves were fully published and discussed a short while ago.

Since 1918 the Ochrida and Prespa region have been allocated to Jugoslavia, and are now some few miles from the northern frontier of Greece. The Jugoslav authorities recently decided to resume investigations at the spot—known as Trebenishte—where these surprising finds were made. Their research, carried out by Professor Vulitch of Belgrad University under the auspices of Prince Paul of Jugoslavia, has resulted in the discovery of an eighth grave even richer than the preceding seven. The contents illuminate without confuting the tentative conclusions arrived at about the others.

Briefly, the eight graves contained burials which bore a striking similarity. The dead in each case were warriors, armed with swords, spears and helmets and adorned with trappings of remarkable interest and beauty. In the first seven graves great bronze craters, wine-jugs and tripods of the finest Greek work of the sixth century were found. One bronze volute-crater which stands sixty-eight centimetres in height is, perhaps, the finest Greek bronze vessel in existence, rivalled only by one in Munich. A bronze jug with a handle in the form of a small male figure is the finest example of its kind. But in addition there was a group of silver two-handled vases of great beauty, and—most curious of all—a number of beaten gold grave fittings not hitherto found in any known Balkan burial. One warrior had a gold face-mask, and on one hand a gold glove with a thick gold ring round one finger. Another had a gold mask only and a third a gold pectoral on his breast.

A MASK IN BEATEN GOLD.
The nature of the new discoveries is further evidence that the cemetery was a royal burial ground. Gold masks were worn only by persons of high rank.

The eighth grave just discovered contains, among a particularly rich group of objects, another gold mask, a gold glove and a pair of gold sandals. All these masks and other grave clothing, it should be remembered, are of thin beaten gold but richly decorated in repoussée with beautiful designs. They are all essentially clothing for

the other world, fabricated with half an eye towards economy, as was so often the case in Greek burials! For the Greeks were quite content to believe that Charon would be deceived by a tinsel coin and the shades of the dead misled into supposing that gold leaf was as good as solid. Besides the grave trappings, the eighth grave has also produced a superb helmet decorated with a rim of gold appliqué and with the figures of horsemen on the cheek flaps, which is unique in our knowledge of Greek panoplies; the upper and most important part of a volute-crater even finer than that discovered in 1918; a tripod the legs of which are supported by three gorgons and the intervening spaces by running hounds; a large amber necklace; a silver-gilt drinking horn fifty centimetres long and in perfect condition, and a silver-gilt goblet; two bronze tripods of simple form and a small bronze jug. Finally, there is a small group of silver pins and brooches.

A UNIQUE DISCOVERY.
Among the new finds is this helmet decorated with gold appliqué, which is unique in our knowledge of Greek panoplies. On the cheek flaps are figures of horsemen.

Before attempting to explain the presence of the graves and their wealth in the heart of one of the most desolate regions of the Balkans, far from the principal ancient centres of Greek life, it may be profitable to analyse the character of the most important objects which come from the latest grave. The drinking horn and the goblet are almost replicas of similar vessels from the first and fifth graves respectively; in fact, they might well have been made by the same silversmith. There is nothing about them to suggest that they were not made by a first-rate Greek craftsman. The Medusa-tripod and the top of the volute-crater belong together, the crater being found in a position which indicated that it had stood upon the tripod. The two are masterpieces of Greek art of the sixth century B.C. The crater bears the figures of galloping horsemen in high relief, while the volutes are decorated with winged gorgons draped in scaly garments and the rim of the vessel with a simple and lovely fluting. The tripod is supported by full-length winged gorgons which surmount three claw feet.

Of the entire grave-group from this grave, and, indeed, in the necropolis as a whole, this is the most surprising and beautiful bronze. It seems to have been made by the same artist who made the volute-crater of the first grave, whose rim is decorated with cattle as this one is with horsemen. The similarity between the two is in technical detail almost exact. On the whole it may be said that there is nothing in the eighth grave that is un-Hellenic except the silver pins and brooches, which are in type quite certainly to be identified as replicas of Illyrian pins found in burials of the early Iron Age in Bosnia, Dalmatia and Central Macedonia. In the other seven graves, however, were found a certain number of bronze vessels which differed in quality from those which were definitely Hellenic. These were thought to be barbaric copies of Greek work.

Since the publication of the earlier graves there has been a certain amount of interesting controversy concerning them. Professor Keramopoullos of Athens has called attention to the fact that the only parallel for the strange masks of gold is with the masks of the Shaft Grave burials at Mycenae, and he suggests that here in the heart of the Balkans has survived a burial custom which may itself be essentially a mainland Balkan custom adopted by the rulers of Mycenae. For this view there is the additional support of the silver pins, which represent a survival into the sixth century of a type common in the ninth and tenth. Evidently in these remote mountainous regions survival was easier than in the ever-invaded plains of Thessaly, Central Greece and the Argolid. But it must be admitted that this view is mere hypothesis.

Professors Filov and Schkorpil, who have published the first seven graves in a most thorough and illuminating monograph, raise the thorny question of

the occupants of the graves. Who were they and how did they come to reach this remote spot? The professors believe that they are the bodies of Greek mercenaries serving with the semi-barbarous princes of Lynkestis, whose raids upon the settled plainlands of the Vardar were frequent and disastrous. Certainly Greek soldiers were serving under Perdikkas of Macedonia in 423 B.C., recruited from the Greco-Macedonian cities of the plains, and such service may well have existed at an earlier date. But the serious, if simple, objection to this view is that Greek mercenaries from those parts were poor men, badly equipped, and they were hardly likely to carry with them such vast accumulations of heavy treasure. Nor would they have been buried in such obvious state. Tombs of such Greeks have, in fact, been found near Salonika, at Zeitenlik on the one hand and at Karaburun Cape on the other. In each case, while the graves were the same in structure as those of Trebenishte, the contents were simple and poor; helmet, sword, vases of clay and in most cases small gold plaques for covering the lips. The date of these burials corresponds with that of the Trebenishte cemetery.

RIM OF A BRONZE CRATER.

This masterpiece of Greek art of the sixth century B.C. is fashioned in bronze, and bears a striking similarity to the unique crater found in a previous grave. The volutes are decorated with winged gorgons.

It seems unlikely, then, that the Trebenishte graves are those of soldiers killed in a remote battle. Their wealth and the indications of elaborate ritual which the gold trappings suggest must mean that they are the graves of princes of some royal family. But the majority of the objects in the graves are, strangely enough, not only apparently of the same date 520-500 B.C., but seem very largely to come from the same workshop and many of them from the hand of the same artist. The goldwork in particular appears to be all from the same hand. We have to deal, then, with the burial of eight royal or princely warriors all of whom died on the same occasion. But here history fails us. What we know of the history of these regions in the sixth century is most fragmentary. Macedonia was ruled by an able king, Amyntas I, between the years 540 and 498, the period of our necropolis. Amyntas allied himself with the Persians by marrying his daughter to a Persian noble and received an embassy from Darius after the return of the Persian expedition to Scythia in 510 B.C. But on his west flank were a number of independent cantons, Elymia, Lynkestis and others, ruled by independent chieftains who were perhaps as much in touch with Hellenism as he was, for they had not only the Macedonian towns to draw from but were also in touch with the Corinthian settlements on the Adriatic. The passage through their territory of the route which later became the Via Egnatia (to-day it runs from Salonika to Durazzo), made such communications still easier.

We hear of Derdas of Elymia and Arrhibaios of Lynkestis in the fifth century challenging a Macedonian King on his own ground. And we know of other tribal kings in the sixth century who ruled over Paeonian tribes between Lake Ochrida and the Vardar. But still it remains difficult to account for such wholesale mortality in any of these princely kingdoms. Conceivably the burials contain the dead from some extensive massacre. For treachery was not uncommon in these feudal states. We know from Herodotus that Alexander I of Macedon, the successor of Amyntas, massacred at a banquet the seven Persian ambassadors whom Megabazus the satrap had sent to him after the Persians had subdued Paeonia. Conceivably these semi-Hellenic burials represent an earlier destruction of Paeonian princes by the Persians during their conquest of the Paeonian canton, an event for which the banquet of Alexander might have been a later retaliation. In any case, it is only by an explanation of this kind that we can account for the burial of seven chieftains at the same time, all apparently of the same rank and importance. The proximity of the burial place to the Egnatian route and to the ancient town of Lychnidus on Ochrida suggests that the events that brought about their death occurred near

a route that led from the east. Megabazus, we know, attacked from the east and invaded Paeonia by an inland route. He subdued the Paeonians ruthlessly and deported the bulk of them to Asia. In the process he may well have exterminated a royal house.

The royal or princely character of the graves seems indisputable. No ordinary Greek soldier was ever buried in such state as this, and those who served in the armies of Illyrian or Macedonian kings and princes were certainly poor men. What seems, most of all, to indicate that the burials are of the members of a royal family—perhaps the sons and nephews of a king, with perhaps the king himself—is the presence in the tombs of certain distinctive objects. The helmet with decorations in gold appliqué could only have been worn by a notable personage; the masks over the faces indicate as great importance as do the masks over the faces of the princes of Mycenae. The parallel is sound and inevitable. Commoners in no land are buried in such pomp. But here the parallel with Mycenae ends, unless indeed the ritual significance of the masks is the same in both places and the rite a late survival from prehistoric times. The Mycenaean princes were of several generations. They were buried in a royal necropolis that covered at least a century of time. But here at Trebenishte on Lake Ochrida the graves are all contemporary. Some of the objects, it is true, seem to be properties that had been in the royal court for some years before the date of the burials. The great bronze craters were probably made about 550 B.C., and some of the other bronzes are equally early. But there is nothing that can conceivably be dated later than 500 B.C. and the latest date gives, of course, the date of the interment. Each grave contains objects of the latest date, 500 B.C., so that all the graves must be contemporary.

A GOLD SANDAL.

The sandals, made of thin beaten gold but richly decorated in repoussée, are essentially clothing for the other world.

We must imagine, then, some event like the invasion of disciplined Persian troops into these wild regions. They were engaged upon a ruthless subjugation of the Paeonian and other mountaineers, who had given Darius considerable trouble and caused great anxiety while he was engaged upon his more arduous task of attempting to impress the vast hordes of the Scythians with the might and power of Persia. This Scythian expedition of Darius advanced in 510 B.C. across the Bosporus and along the Black Sea coast of Thrace. During the whole time the left flank of the Persian army was exposed to flank attacks from the wild tribes of Thrace and Paeonia. Macedonia had, for the time being, been made to come to terms. After Darius had returned from Scythia to Thrace and thence to Persia he saw the vital importance of subduing these enemies on the west. The satrap Megabazus was given the task.

On such occasions the Persians would be ruthless and their enemies no less so. The Paeonians throughout Greek history were noted for their independence of spirit and fine fighting qualities. Their subjugation would no doubt have been a dangerous and an onerous task, but we can be sure that it was efficiently done. Herodotus leaves us no doubt on this point. The Paeonians were subdued and the bulk of them deported to Persia between 510 and 500 B.C. For this we have independent archaeological proof. But the first measure the Persians would have adopted would have been to capture or exterminate, by fair means or foul, the leading dynasts of the Paeonians and their allies. The method of the banquet, to which local potentates were invited to discuss terms and

then murdered, was a method of long standing in the east. Some such method was probably followed in this case and the bodies of the slain given back to their followers and womenfolk for burial according to their traditional rites.

There remains the problem of the provenance of the Greek bronzes. If, as is generally believed, they are mostly of Corinthian fabric, then the Adriatic towns near the exit of the Egnatian route, such as Apollonia and Epidamnus, would have served as the middlemen. Alternatively, Corinthian Potidaea might have provided merchandise of this type; the half-way position of Trebenishte between the two seas makes this a distinction with but little difference. Of the burial cults and the meaning of the gold masks we know nothing, except that it was at least a Macedonian custom to cover the lips with a gold plaque, a practice which in the case of richer folk might have led to the use of a complete face-mask. The fact remains that no such find has ever been made so far north. It is eloquent testimony to the penetrative power of Greek taste into the remote lakes and highlands of the Balkans and to the adoption by barbaric tribes of Greek modes and customs.

Correspondence.

PEKIN MAN.

To the Editor of DISCOVERY.

SIR,

In an editorial note on Pekin Man in the March issue of *Discovery*, it is stated that the discovery of the Pekin skull enables us to picture the nature of the common ancestor of Java, Pekin and Piltdown Man—the hypothetical Pliocene man. By this I understand that no ancestor of these has yet been discovered, but that it is certain he lived in Pliocene times. Was not such an ancestor found in the Taungs skull, *Australopithecus Africanus*? It will be recalled that this skull, discovered in South Africa in 1925, was put forward by Professor Dart as probably that of an immature specimen of a primitive human type, a child of about six years of age. Mr. Robert Broom issued a geneological table of man which showed the Taungs skull as a Pliocene form of man standing in the direct line of human descent as a precursor of *Pithecanthropus erectus*. This should prove that Taungs Man is older than Java, Pekin and Piltdown Man, and the conception of a hypothetical ape-man who lived in the Pliocene age is inaccurate.

Yours faithfully,
GEORGE G. UNWIN.

South Shields, Co. Durham.

The prospect of the Taungs skull as a Pliocene form of man standing in the direct line of human descent as a precursor of *Pithecanthropus erectus* is attractive. But clearly the view expressed by Professor Elliot Smith that Pliocene man is as yet hypothetical must stand. According to the latest interpretation of the geological evidence, the Taungs skull belongs to the Lower Pleistocene, and it is now generally accepted that the skull is not human but that of an immature anthropoid.—EDITOR, *Discovery*.

THE GREEN FLASH.

To the Editor of DISCOVERY.

SIR,

It seems worth recording an observation of the Green Flash which I made at Thandaung, in Burma, a hill station situated at about five thousand feet in the Karen Hills. During the monsoon it is almost completely enveloped in cloud, but early in October, at the break of the rains, the mists become partially dispersed, and the visibility is at times very good. At the time of making the observation I was on one of the highest peaks of the range, the valleys below being almost completely enveloped in mist, but at the higher levels the visibility was distinctly good. As the sun set over a hill, approximating in height to that from which I was observing it, the disc for an instant flashed a brilliant green. It did not appear to me to exhibit the yellowish green transition stage which other observers have described.

I should add that on various occasions, and at different stations in the East, I have endeavoured unsuccessfully to observe the phenomenon. On subsequent occasions, extending over a week, I endeavoured to observe the effect at Thandaung without further success, but as the fine weather had set in and the mist had dispersed, I never had an opportunity of making an observation under the conditions described above. Is there any reason why such conditions should be favourable for an exhibition of the phenomenon?

Yours faithfully,
J. A. C. TEEGAN.

Holt, Norfolk.

The Green Flash is an interesting meteorological phenomenon about which much has been written. The most likely explanation appears to be that, when the sun is low, our atmosphere disperses its light and gives images of it in the different colours of the spectrum. The red image is the brightest, as light of long wave-length penetrates the atmosphere more readily than that of shorter wave-length; the blue and violet images are practically extinguished by atmospheric absorption. The red image, being least refracted, is at the bottom, and sets first; then the green image is seen for a moment before it sets in its turn. The green effect is sometimes ascribed to contrast; thus, when the sky is red through sunset glow or through the glare of a conflagration, the moon often looks green. Some observers, however, claim to have seen the Green Flash at sunrise, when contrast would be excluded. It is doubtful whether the mist really contributed to the visibility on the occasion described by our correspondent. If it did, the mist may possibly have excluded the blue and violet images more completely than usual, which would give a purer green than is normally seen. This suggestion, however, is offered with diffidence.—EDITOR, *Discovery*.

Excavating the Agora of Athens.

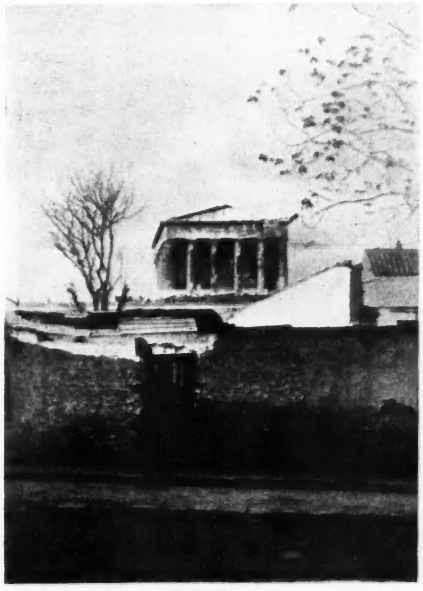
By Theodore L. Shear, A.M., Ph.D.

Lecturer in Archaeology, University of Princeton.

For nearly a hundred years excavation of the Agora of Athens has been contemplated but lack of adequate funds has prevented the realization of the project. The financial support of an anonymous American has now been enlisted, however, and this important work is shortly to be commenced under the direction of Professor Shear.

THE market place was the centre of the life of ancient towns. In the market men gathered for barter and trade, here the news of the day, whether real or imaginary, was passed from mouth to mouth, here sages discoursed, bards sang and dandies promenaded. As towns expanded in size and increased in wealth and in importance public buildings were erected in the market place, such as porticoes for the use of the loungers and the philosophers, senate-houses for the law-makers and temples for the gods. Thus the market places gradually developed into civic centres and the markets for trade were moved to adjoining areas.

The original meaning of the Greek word *agora* was a place of assembly. It corresponds with the Latin word *forum* which means a place with fixed bounds. The site of the agora of Athens is approximately determined by descriptions and references in the works of ancient Greek writers. Pausanias, the learned traveller who made a tour of Greece in the second century of our era, describes his visit to the agora and mentions a series of buildings there. But Pausanias did not aim at writing a guide book, and with the disappearance of the buildings which are mentioned by him, his route through the market is conjectural and the sites of the monuments are unknown. The permanent geographical features of the terrain, however, permit its approximate delimitation. The agora is roughly bounded on the west by the Hill of the Agora, Kolonos Agoraios, and on the south by the Areopagus and the Acropolis. The eastern limit has been revealed by previous excavations which have uncovered a large Roman market close to the Tower of the Winds, or Horologion, erected by Andronikos Kyrrhestes in the first century B.C.



WHERE EXCAVATIONS WILL BEGIN.
These buildings will be the first to be excavated. In the background is the Theseum, a temple dedicated to an unknown god.

A conspicuous landmark of this district is the well-preserved temple on the Kolonos Agoraios, but unfortunately it is uncertain to whom this building was dedicated. It is traditionally known as the Theseum, but this attribution is universally rejected by archaeologists. They do not agree, however, in identifying the building as the temple of Hephaestus. Thus the preservation of this monument does not assist in the topographical interpretation of the description of Pausanias.

A Roman structure on the northern side of the agora, which was excavated by the Greek Archaeological Society in 1859 and in 1871, is called the Stoa of the Giants from the sculptured figures which were there uncovered. But this building cannot be identified with any of those named by Pausanias. Nor does Pausanias refer to the large Stoa of Attalos on the east side of the agora, which has also been excavated by the Greek Archaeological Society. It is thus clear that in his description of Athens, as in that of other places visited by him, Pausanias did not record every monument which he saw; his method was eclectic and therefore his guidance is difficult to follow.

Despite his omissions, the number of public buildings and monuments in the agora mentioned by Pausanias is large. The first structure on the right as one entered from

the Dipylon, that is, in the north-west corner of the market, was the Stoa Basileios, the Royal Stoa, which still in the Roman period was decorated with archaic figures made of terra-cotta. Copies of the laws of Solon and of other important laws were placed in this hall. Professor Wilhelm Doerpfeld identifies the site of this building with some foundations below the hill of the Theseum which were excavated by him in 1896-1897, but conclusive evidence in support of this view was not discovered and the identification seems improbable. Apparently not far from the Royal Stoa was situated the Painted Stoa, Stoa Poikile, which was famous because its walls were decorated with paintings by Polygnotus, assisted by Mikon and Panainos. The decorations represented scenes of the capture of Troy, of the Battle of Marathon, and of the fight between Theseus and the Amazons. A bronze statue of Solon stood in front of this building.

A STREET IN THE AGORA.
Aeschines Street is typical of the narrow thoroughfares in the Agora. Demolition of the houses is shortly to be commenced.

Beyond the Royal Stoa on the west side of the market was another stoa, that of Zeus Eleutherios, which had on the walls of its inner hall paintings of the twelve gods by Euphranor, and other painted scenes. Important documents inscribed on stone were also deposited here, and in front of the building stood a statue of Zeus, the Saviour. Other statues of prominent men were dedicated near this place. This stoa, like other halls of a similar character, was furnished with benches and thus provided a place of assembly for large or small groups of persons. Somewhat farther to the south, in the same part of the area, was the temple of Apollo Patroos with a cult-statue made by Euphranor. A statue of Apollo by Leochares and one by Kalamis were erected in front of this temple.

After the temple of Apollo, Pausanias mentions the Metroon, which was therefore presumably situated in the south-west part of the agora. The Metroon, or temple of the Mother of the Gods, contained a cult-statue by Phidias, and was the depository of the archives of the State. The worship of Demeter was here associated with the Eleusinian cult and the precinct of the Metroon was the starting place of the annual sacred procession to Eleusis. The Senate House, Bouleuterion, must have stood close to the Metroon. In it were deposited copies of laws and treaties, decrees and official lists of magistrates. Paintings were on its walls and statues were placed in its halls. Many other public monuments are mentioned as being situated in the agora. The Tholos was the worshipping place of the prytanes, the orchestra was the site of the earliest dramatic performances in Athens, the temple of Ares contained a cult-statue by Alkamenes. Among the statues erected outside buildings were those of the Eponymous Heroes who gave their names to the tribes, of Eirene and Plutus by Cephisodotos, of Lycurgus and of Demosthenes. The famous bronze statues of the Tyrannicides were erected in a place opposite the Metroon.

It is thus evident that in and about the market place of Athens were clustered the important public buildings of the city, that here were deposited the government records, and that here splendid works of art were dedicated. The recovery of these buildings and objects would add immeasurably to our knowledge of the topography, history and art of the city. The desirability of excavating this area was recognized by the Greeks as soon as the country was freed from Turkish rule, and in 1833, when Otho was King of Greece, the entire terrain was expropriated for the Government by a decree as an archaeological area. The value of the land was assessed at seventy lepta a square pique, a price that is equivalent to about sevenpence for a little more than five square feet. But the early years of her independence were difficult times for the new government, and funds were not available with which to carry out the project at the time. The plan was therefore postponed but never abandoned, and periodic attempts were made to revive it. Small excavations were conducted in parts of the area by the Greek Archaeological Society and by the German Institute at Athens, but the great expense involved in the purchase of land

and houses prevented the undertaking of operations on a scale commensurate with the extent and importance of the site.

In the meantime, the city of Athens has vastly increased in size and wealth, with the result that the value of property has proportionately advanced. In the hope of seeing the fruition of a long-cherished plan before the costs became prohibitive, the Greek authorities offered this project several years ago to the American School of Classical Studies at Athens through Dr. B. H. Hill, director of the School at the time. The Administration of the School in America enthusiastically welcomed the opportunity, and Professor Edward Capps of Princeton University, trustee of the School and chairman of its managing committee, proceeded with his customary zeal and succeeded in enlisting the interest and financial support of an American citizen who wishes to remain anonymous.

As soon as the financial guarantee was secured plans were begun for the practical realization of the project. The terrain is a large one, comprising some twenty-five acres, on which are situated hundreds of houses with thousands of occupants. Many of the houses are small and dilapidated, but some are substantially built and are in a good state of repair. In order that the valuation of the property might be made with perfect justice to all the parties concerned a special law of expropriation was passed by the Greek Government in 1929. Throughout the difficult and delicate negotiations, which were skilfully and tactfully directed by Professor Capps, the project had the constant support of Greece's brilliant premier, Monsieur Venizelos, and it received the hearty co-operation of Dr. K. Kourouniotes, director of the Department of Antiquities in the Greek Ministry of Education. The interests of the School were ably represented in Athens by its present director, Dr. Rhys Carpenter, and by the business manager of the agora excavations, Mr. A. Adossides, a former Governor of Eastern Macedonia.

A VIEW FROM THE WEST.

This view of the Agora from the west shows in the foreground the excavations below the hill of the Theseum made by Professor Doepfeld in 1896.

After a study of the area of the agora and a full consideration of the magnitude of the task of its excavation, it was decided by the authorities of the American School, in consultation with the Greek Archaeological Society, that the site should be divided, and that the Greek Archaeological Society should assume the obligation of excavating the eastern part, where they had previously done extensive work, and that the American School should clear the western part, which is assumed to be the site of the specifically Greek market place. The American section is bounded on the north by the Athens-Peiraeus electric railway, while on the east it extends to the east side of the Stoa of Attalos, and thence south to the Acropolis. The southern limit is set by the Acropolis and the Areopagus. The Hill of the Theseum, the Kolonos Agoraios, is the western boundary. The American section includes more than three hundred parcels of land, nearly all of which are occupied by buildings. In order to enhance the possibility of finding, in the early stages of the work, a building which may be identified with one of those mentioned by ancient writers, it is proposed to begin excavations in six different blocks. This tentative project involves the expropriation and demolition of fifty-five houses.

ENTRANCE TO THE ROMAN MARKET.

The eastern boundary of the Agora has been revealed by previous excavations, which uncovered a large Roman market erected in the first century B.C.

Because of the large property interests which are affected by the excavation programme, the law established an equitable procedure for determining the present value of the land and of the buildings which are situated upon it. A commission of valuation was appointed of which the personnel is composed of technical and financial experts, and on which the interested proprietors and the American School have equal representation. The President of the commission is the learned jurist Malevitis. The commission has been meeting regularly since the autumn of 1929 and has been very thorough in its investigations. It has reported its conclusions as to the value of parcels of property in two of the sectors where excavations will be begun. One of the proprietors exercised the right of appeal to the Supreme Court, the Areopagus, as is permitted by the terms of the law of expropriation. The judge of the Areopagus appointed a second commission to investigate and report on the value of the property in order that he might be assisted by specialists in reaching a decision on the issue. The second report, which was adopted by the judge as the basis for his verdict, recommended a valuation slightly in excess of that approved by the first commission, but the decision was accepted by the authorities of the School and the property has been expropriated. According to the provisions of the law, the occupants of the houses have been served with notices to quit, and they must leave in the course of three months. Besides the property thus expropriated, several lots have been purchased by private sale. Unless further unforeseen difficulties arise, therefore, the demolition of the houses should be begun this spring, and in that case the archaeological excavations will immediately follow.

It is planned to begin excavations below the hill of the Theseum to the north and to the east of the site cleared by Professor Doerpfeld. The aim of the work in this area is to locate the Royal Stoa, the Stoa of Zeus Eleutherios and the temple of Apollo Patroos. Subsequently, work will be undertaken in a sector which lies farther to the south-east in a search for the Metroon and for the Bouleuterion.

Thus, after a delay of nearly one hundred years, the prospects are now excellent for the uncovering of the market place of the ancient Athenians, and with the firm support of the Greek statesmen and archaeologists, the co-operation of the American School and the assistance of the anonymous donor, the work should proceed rapidly under happy auspices.

How Science is Assisting the Physician.

THE growing influence of the primary sciences in the sphere of medicine is indicated in the annual report of the Medical Research Council. Work in the laboratory with microscope or test-tube has progressively assisted practical observations. Problems have increasingly been taken from the bedside to the laboratory for their solution, while the laboratory has repeatedly produced independent ideas for clinical inquiry as well as detailed methods for its pursuit. Scientific research has materially increased the knowledge of forms of life which cause or convey a variety of human diseases. The structure and life histories of insects, worms, protozoa and bacteria have thus been intensively studied.

Progress has been made in developing methods of precision in the measurement of new therapeutic agents. The report shows how the old armament of drugs, many of which owed their effectiveness to some indirect and uncertain action, and many of which were only accessory or palliative, is being enriched or displaced by biological agents obtained from the animal body itself—of which diphtheria antitoxin, hormones of the pancreas (insulin), pituitary body, liver and stomach, and some of the vitamins, may stand as types for many others. By using these the physician can imitate with precision known and often measurable processes of body function. These substances, as well as some of the newer synthetic remedies such as the arseno-benzene compounds, are incapable of assay by direct chemical means. Intricate methods have to be devised in the laboratory for their measurement and standardization.

The studies of gas tensions in the tissues has now been completed. Experiments on life at low oxygen tensions have shown that mice, though at first showing the blood changes of acclimatization to high altitudes, cannot continue to live healthily after a month at an oxygen tension corresponding with a twenty thousand feet altitude. Restoration to a normal oxygen tension, for one hour in each day, did not improve their resistance to an otherwise persistent low tension. Mice being in general more resistant to such changes than large animals such as man, the experiments strongly suggest a limit to possibilities of acclimatization at the high levels already reached by man for short periods for purposes of exploration.

South America : (2) The Panama Canal.

By John A. Benn.

The Editor of DISCOVERY *has now reached Chile, after completing the first part of his tour in South America. He describes the journey through the Panama Canal, which is not only one of the seven wonders of the modern world, but is associated with the most romantic period of Spanish history.*

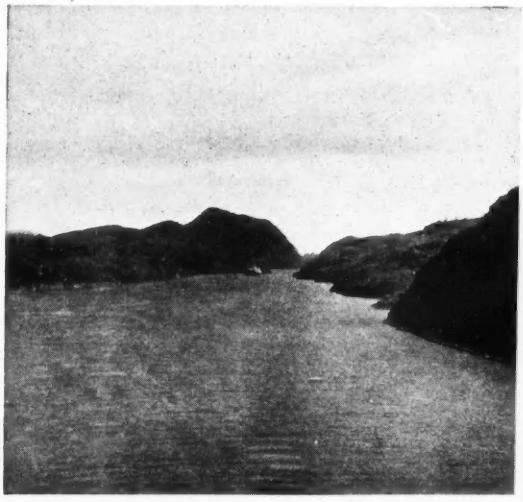
THE word "canal" gives a very limited impression of Panama. On Gatun Lake, nearly two hundred square miles in area, the ship might seem to be crossing an inland sea, were it not for the buoys which indicate the navigable channel. The day's journey was the most interesting I have ever made.

On the Atlantic side of Panama the canal was formed by damming the Chagres River. The effect has been to produce this immense artificial lake in the hilly mainland, 85 feet above sea level, in which the water is retained by locks. Half-way across the isthmus the steamer passes Darien, where a large wireless station stands near the peak from which Balboa first saw the Pacific, four hundred years ago. The canal is here joined to the ocean by the Culebra Cut, blasted through solid rock for a distance of eight miles. Then come the Pedro Miguel and Miraflores Locks, which lower the ship by three stages to the Pacific level.

Passing through the Panama Canal is still a voyage of discovery. The war obscured it from the public view for five years, following the opening in 1914, so that the canal has been general knowledge for barely a decade. So little are its marvels known, even by the Americans, that two New York papers printed quite matter-of-fact articles last month describing this journey.

The efficiency of the canal to-day makes it hard to remember the terrific sacrifice by which it was achieved. To the thousands who lost their lives on the fever-ridden isthmus must be added the huge toll of mariners shipwrecked in attempting to round Cape Horn. As early as 1526 the Spaniards had plans for cutting a canal, but meanwhile their galleons were trying to find a sea route to the west. On this quest alone over two thousand men perished, and of the twenty vessels which set out to make the passage only one—Magellan's *Vittoria*—returned home to Spain. It was left to Sir Francis Drake fifty years later to discover Cape Horn, before he sailed up the west coast to sack the wealthy towns of Peru.

For a time the sea route was abandoned in favour of the Gold Road of Panama, built across the isthmus by slave labour with huge blocks of stone. The modern traveller can see from his ship the dense forest surrounding Gatun Lake on every side. A railway and a tarred road run close to the canal but do not obscure a vivid impression of the jungle, still unsurpassable off the beaten track. The labour required to build a roadway with the crude machinery of four centuries ago, and the enormous loss of life from fever and the attacks of animals, can scarcely be imagined. It was disease more than engineering difficulties which caused the French to fail when the digging of a canal was first attempted in 1881.



ENTERING CULEBRA CUT.

At Darien, the Panama Canal is joined to the ocean by the Culebra Cut. This channel was blasted through solid rock for a distance of eight miles.

The route chosen by Ferdinand de Lesseps began at Simon Bay, like the modern canal, but was to cross the isthmus in a slightly different direction. Nineteen miles were constructed at a cost of £50,000,000 before the enterprise was abandoned in 1891. Some years later the construction rights were sold to the United States and the canal was completed in 1914 at a further cost of £75,000,000.

Side by side with the engineering problems, the task of stamping out yellow fever and malaria was started by Colonel Gorgas, whose discoveries have been responsible for making the territory healthy and efficient. His work is being continued to-day in Panama City at the Institute for the study of tropical diseases.

There were many problems to be solved before the canal was ready for service. Enormous quantities of rock had to be excavated, and just as the construction appeared complete a difficulty recurred which had defeated the French engineers thirty years before. In October, 1913, the water was let into Culebra Cut, the feat being performed by President Wilson who pressed a button in Washington, two thousand miles away. By this means the temporary Gamboa Dam was blown up, and the water of the Chagres River formed Gatun Lake, flowing thence into the Cut. Here, however, a giant mass of rock, named by the French the Cucaracha Slide, began to move again and blocked the canal for almost another year. In the same region a slide occurred in 1915, closing the canal for six months. A final slide, in 1920, was dealt with so rapidly by the American engineers that the passage was cleared within twenty-four hours.

IN GATUN LOCK.

A view of the lock from the ship in which the Editor sailed through the canal. The locks are over a mile long and ships are guided by means of electric "mules," seen on the left.

The canal is controlled by a military governor, and there is a strong garrison of troops and aircraft in the zone. More than six thousand ships pass through the canal every year, and Panama receives a rent of £50,000 from the United States Government.

A statue to the French pioneer, Lesseps, has been erected in a picturesque square at Cristobal. This modern city adjoins the native town of Colon, at the Atlantic end of the canal. With palms growing along the water front, the anchorage presents a quaint scene only marred by the advertisement hoardings of some tobacco companies. After crossing the harbour, the ship enters a straight cut approaching Gatun Locks. The banks are thick with tropical vegetation and occasional clearings reveal native huts thatched with palm leaves. This first section is certainly an orthodox canal. On reaching the locks, which are over a mile long, the ship is attached to electric "mules," four on each side, to guide it through. Each lock is 1,000 feet long, 110 feet wide and 70 feet deep, dimensions which just allow a clearance to the largest ships. The water is regulated by gravity and no pumps are used in the canal system.

The electric power station is built on the left bank of the Gatun dam, a massive structure over a mile long and half a mile wide at its base. On the other bank is a golf course, situated on the most expensive piece of ground in the world used for this game. An American summed up the scene in a sentence. "You cannot help feeling," he said, "that natives and alligators and Nature herself must take every cry of 'fore' as a personal insult."

As the locks recede into the distance on Gatun Lake, the sense of being at sea gradually recurs. The river water has submerged so much of the country that the boundaries cannot be determined from the ship. The tree-tops are perhaps the most amazing feature of the lake. After sixteen years the roots, one imagines, would have rotted, but there are still dead branches peering above the water. In some places two or three dozen trees appear in a cluster, the last brave survivors of a wood which grew on a hillock now submerged.

Of all the features of the canal the animals alone disappointed us. Or perhaps the guide-book was to blame. In an earlier article* I referred to the island of Barro Colorado—Spanish for "red mud"—where I hoped that the animals in their wild state would be seen from the deck of the steamer. Actually, the only indication of their presence was a notice nailed to a tree, stating that the island is a preserve of the National Research Council, Washington, U.S.A. In

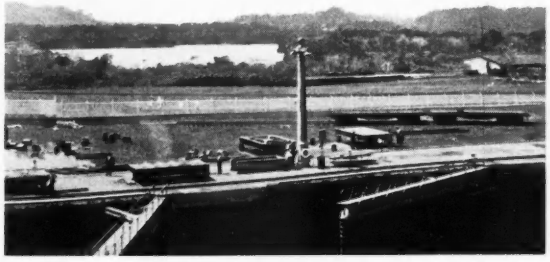
* "South America: (1) Exploring the Map." *Discovery*, February, 1931.

the interior there are specimens of every animal native to the Panama area, believed to number more than two hundred species, but they are seldom seen from the big ships. A small boat would no doubt reveal some of these animals, especially lizards and alligators, but they are usually frightened away from the shore. Though we saw no signs of them at Barro Colorado, a small alligator obliged us in the Culebra Cut, showing its brown head and jaws before slipping under water as the steamer passed by.

Lovely blue birds like small herons were also seen in this part of the canal, and earlier, in the Gatun Locks, some sharks had appeared in our wake. As I looked at these angry fish from the safety of the deck I did not envy Richard Halliburton, the young American writer who swam through the canal a few years ago. He did this " stunt " in stages, but even the presence of an expert rifleman, who kept watch for sharks from a dingy, cannot have removed the constant apprehension from the swimmer's mind.

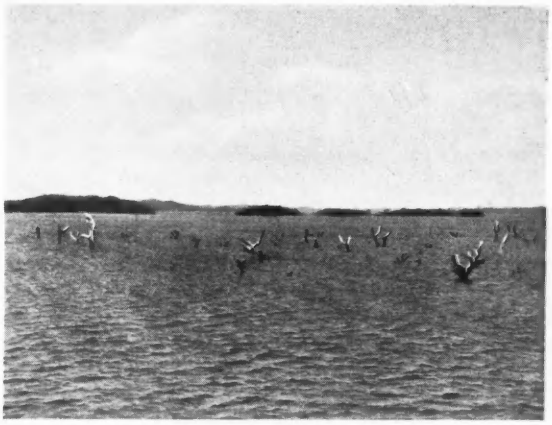
The only other fish seen in this part of our journey were flying fish, which we first saw in the Caribbean Sea. Sometimes a single fish will jump a few inches out of the water, at others several dozen fly together, travelling a hundred feet or more across the surface. These fish might easily be mistaken for small white birds.

Owing to the stable weather at Panama, the conditions for aviation are excellent all the year round. A regular air service crosses the isthmus three times daily, and since its inception in May, 1929, the machines have flown every day without a break. The journey by air takes only half-an-hour, compared with two hours by train and eight hours on ship. Seaplanes are used, as the route taken follows the canal closely. The service has the advantage of enabling sea passengers to cross the isthmus quickly, so affording more time in Cristobal or Balboa. But I doubt whether the flight can give an adequate impression of the tremendous engineering feat which the canal represents.



THE GOLF COURSE ON GATUN DAM.

This golf course is situated on the most expensive piece of ground in the world used for the game. The massive lock gates are seen in the foreground



TREE-TOPS IN GATUN LAKE

A remarkable feature of the lake is the dead tree-tops which peer above the water, the last survivors of a wood which grew on a hillock now submerged.

At every stage of the passage through the canal one is struck by its efficiency. The locks and surrounding buildings are " model " villages. Every piece of metalwork is painted, the lawns, though parched, are carefully mown, and each lock is fenced in with wire netting. And the working of the locks is as efficient as their appearance. There is no fuss or noise—not even the ringing of bells—and the only signals are the siren blasts which all ships must make at certain points on the route. At Culebra Cut the traffic is regulated by cones and balls suspended on masts, to indicate whether this narrow section of the canal is clear. All the locks are duplicated so that ships may pass in each direction simultaneously.

The *Santa Clara* had left Cristobal at 11 a.m., and we reached Balboa just as darkness was falling over the Pacific. After a day's impressions of modern American efficiency, it was an appropriate contrast to drive through the jungle to Old Panama. In the sixteenth century the port was famous for the gold and silver which were landed from treasure ships to be carried across the isthmus. Henry Morgan, the buccaneer, put an end to these activities by sacking the city so thoroughly that it was never built again. As we stood in the darkness near the desolate ruins of San José Church, the only sounds were the incessant croaking of the frogs and the lapping of the waves on the shores of the Pacific.

Finding Minerals by Physical Methods.

By Captain H. Shaw, D.Sc.

Progress in geophysical methods of prospecting has greatly assisted the discovery of mineral deposits. The exhibition of modern apparatus at the Science Museum makes it appropriate to describe recent developments.

FROM the earliest times man has possessed a natural inclination to forecast the future and to peer into the unknown. For this purpose he has usually employed some form of magic wand. The origin of the divining rod as a guide in this connexion is lost in antiquity, but vague references are to be found in ancient literature to the use of rods in forecasting important events and searching for lost or hidden treasure, while a number of biblical references mention the "rod" in connexion with miraculous performances.

Early Divining Rods.

The Medes and Persians made use of rods for divination, and the Scythians employed them for the detection of perjurers; the Greeks also practised the art of rhabdomancy. The Romans generally used arched rods, but we learn from Tacitus that the ancient Germans employed the branches of fruit trees. The early application of the divining rod was almost entirely on moral grounds—as, for example, in the detection of guilt—although occasional references point to its use in the search for minerals and later for water.

The first published description of the divining rod in its present form, accompanied by an illustration, is contained in Georgius Agricola's "De Re Metallica" which was commenced in 1533 but not published until 1556. A remarkably clear description of the device and its application to the location of minerals is given in a translation by Hoover: "There are many great contentions between miners concerning the forked twig, for some say that it is of the greatest use in discovering veins, and others deny it. Some of those who manipulate and use the twig first cut a fork from a hazel bush with a knife, for this bush they consider more efficacious than any other for revealing veins, especially if the hazel bush grows above a vein. Others use a different kind of twig for each metal, when they are seeking to discover the veins, for they employ hazel twigs for veins of silver, ash twigs for copper, pitch pine for lead and especially tin, and rods made of iron and steel for gold."

According to Barrett, the modern form of divining rod was first used in the mining districts of Germany, and was brought to this country during the latter half of the sixteenth century, when German miners were introduced into Cornwall with a view to resuscitating the mining industry there. Everywhere it aroused controversy, and although the rod has been the subject of innumerable critical investigations, no one has yet succeeded in establishing it as a scientific instrument, capable of furnishing identical results at all times and with different operators. Even now, its use has not been entirely discontinued, and the divining rod as well as other similar unscientific devices is frequently and quite erroneously regarded as a geophysical instrument.

With the development of geology, scientific methods of prospecting came to be applied, but even then the search for mineral deposits was limited to bodies which were to be found outcropping at the surface or lying only at very shallow depths, as the ability of these methods to penetrate below the surface was strictly limited. Naturally the larger and more accessible deposits were the first to be discovered, and as these were developed and worked out, it became necessary to penetrate to greater and greater depths. The ever-increasing difficulty of this task to the geologist, who frequently has to work only from the surface and often with little or no indications for his guidance, is at once obvious. The physicist has, however, developed new and independent methods which are of great assistance to the geologist in enabling him to investigate the subsurface conditions, and these methods are generally known as "geophysical methods."

Centuries of Study.

For centuries physicists have been studying various physical phenomena connected with the earth, such as terrestrial magnetism, earthquakes, and the mean density of the earth, and advantage has now been taken of applying the information thus collected to the elucidation of geological problems. Although applications of the magnetic method to prospecting are known to date from 1640, it is only during the present century that the science of applied geophysics has supplemented the older geological methods, while

the active development of the new geophysical methods, stimulated by the possibility of locating increasingly deeper deposits, has occurred mainly during the past decade. These methods are purely scientific and are based on the fundamental laws of physical science; they have been developed primarily in the laboratory and established subsequently in the field, and have no connexion whatever with the divining rod or any similar method based on the real or imaginary supernormal faculty of certain individuals.

All geophysical methods depend upon the physical properties of the mineral bodies and surrounding rock, and the essential condition for their success in the location and delineation of subterranean anomalies is a variation of one or more of the physical properties, sufficiently marked to be capable of detection at the surface. Most rocks and minerals possess characteristic physical properties, differing in some way from those of adjacent strata, and in consequence it is frequently possible under favourable conditions to establish the position, form and depth of a mineral deposit without the necessity of costly drilling.

AN EARLY DIVINING ROD.

The earliest known illustration of the divining rod, from "De Re Metallica" (1556).

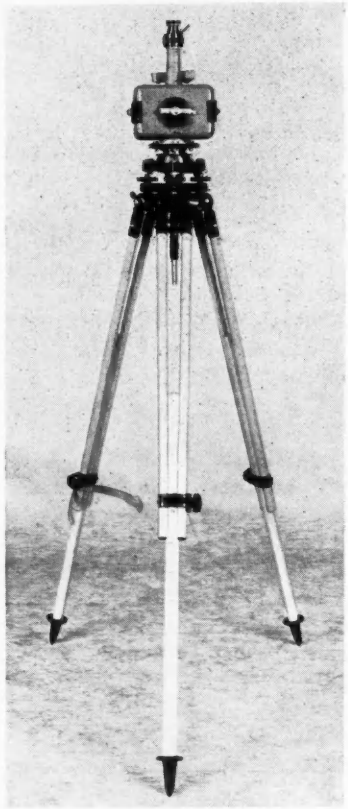
The physical properties most commonly made use of in geophysical surveying are those of magnetic susceptibility, density, elasticity, and electrical conductivity, and by a detailed examination at the earth's surface of the effects resulting from variations in these properties much valuable information can frequently be obtained regarding the conditions existing beneath the surface. There are two distinct ways in which these methods may be applied with success. In the first they are used to examine directly the effects produced at the earth's surface actually by the mineral body itself; in the other case, the direct effect is too small to be detected at the surface, so that efforts are made to locate some other element of the underground structure, which is susceptible to this measurement, and with which the desired mineral body is likely to be associated. Thus it is often possible, by taking advantage of the physical properties of certain rocks associated with mineral deposits to obtain indirect indications of the presence of these mineral bodies. The outstanding example of this indirect application of the geophysical methods is found in the location of oil, which cannot in general be detected directly by any of the methods. But its well-known association with salt-domes and anticlinal structures, which may be readily located and outlined by these methods, is a factor employed to a great extent in the search for oil.

Physical methods are known to have been applied early in the seventeenth century when crude observations on the behaviour of a sundial compass were made in Sweden. By this means it was found possible to locate strongly magnetic deposits occurring at shallow depths, and by the end of the seventeenth century a considerable number of iron ore deposits had been discovered in Sweden by this method. It is obvious that the greatest success may be anticipated with the magnetic method when searching for highly magnetic bodies occurring near to the surface, and owing to the strong magnetic properties of magnetite and pyrrhotite, ores which occur in association with these minerals are particularly suitable for location by this method. Such bodies will naturally distort the magnetic field in their vicinity to a marked degree, but it is not readily appreciated that measurable disturbances exist, due to the varying properties of different feebly magnetic rocks and minerals.

As a result of instrumental improvements, and the consequent increased accuracy of the method, it has now become possible to locate not only strongly magnetic bodies, but also weakly magnetic minerals such as greenstone. Igneous rocks, which are only slightly magnetic, can also be detected, so that the method may be employed indirectly when searching for certain metallic ores known to occur in association with igneous rocks. Even tectonic features such as faults, anticlines and synclines can often be located

and delineated in this way, and the magnetic method is finding increased application in the elucidation of structural problems.

Another method which has been applied extensively is based on the variation of the gravitational field from point to point over the earth's surface. The weight of a body may be regarded as the resultant force exerted between the body and the earth, tending to impel the body towards the earth. This weight does not remain constant from place to place, but varies slightly with the position of the body in relation to the various masses which constitute the earth. It will naturally be greater over dense portions of the earth's crust where the downward attraction is greater, and correspondingly smaller in the vicinity of abnormally light bodies. It is evident, therefore, that in proximity to large and massive mineral deposits, gravity will attain a slightly increased value, which, if it could be detected and measured, might be made use of to indicate the presence of the mineral body. The only satisfactory method of measuring this gravitational force is by means of pendulums, the oscillations of which are observed and compared with those of a standard clock. In this way it is possible by careful observation to make determinations which are accurate to one part in one million, but this degree of sensitivity, although sufficient for the elucidation of extensive structural features, is of little use in the more restricted field of the smaller and purely local anomalies of gravity.



VERTICAL MAGNETOMETER.
This is employed in investigating local variations.

An instrument devised by Baron Roland von Eötvös in 1888 has proved particularly suitable for the examination of the smaller gravitational anomalies, and has been applied extensively in the search for oil and other minerals. This instrument usually consists of a light vertical beam carrying two equal masses, one being fixed at one end of the beam and the other suspended from the other end by a wire. The beam system is supported by a fine torsion wire from a fixed support. A heavy mass buried in the ground at a place behind the instrument will attract the masses, but these two forces of attraction will differ as the mass at the end of the wire is nearer than the other to the heavy mass in the ground. A small twist of the suspension wire will therefore occur, which is magnified optically and measured. This instrument was not intended to measure the actual force of gravity, but was devised to enable the minute variations of gravity over small areas of the earth's surface to be observed directly and with an accuracy hitherto considered unattainable. Its sensitivity was far superior to that of the most accurate pendulums or chemical balances and was regarded as unique. Such a sensitive instrument naturally required careful protection from external disturbances, and although Eötvös enclosed the suspended system in a double-walled metal chamber and an external light-proof tent, his field observations were for many years confined to the night, owing to large disturbances experienced during the day.

Instrumental improvements now enable observations to be made during the day, with increased facility and comfort to the observer, while the recent development of smaller and more portable instruments has enabled surveys to be conducted underground in existing mine workings, in order to ascertain the displaced position of ore bodies which have been disturbed by faulting.

The seismic method is, perhaps, the most fascinating of the geophysical applications. Use is made of the waves from artificial miniature earthquakes, and as these waves are transmitted with different velocities in different rocks, it is possible by careful examination and measurement to determine the position and depth of any large and suitable mass with reasonable accuracy. The velocity of propagation of a seismic disturbance through any medium depends upon the physical properties of the medium, but in general is found to increase with depth. In a homogeneous medium the time interval required for the wave to travel a certain distance will vary directly with the distance, and the curve connecting the time required

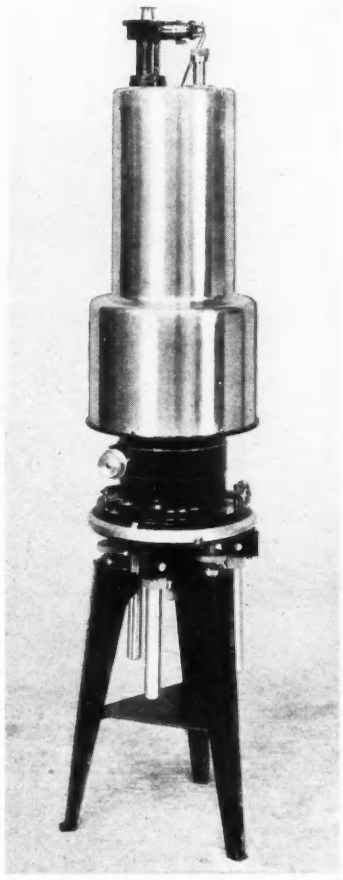
with the distance travelled will be a straight line. Should the wave in its travel encounter a stratum through which it can pass more readily, then the direction of the time-distance curve will be changed, the point of change being marked by a discontinuity.

In order to determine the time required by the wave to travel over a given distance, it is essential that both the time of the explosion and the time of arrival of the wave should be accurately known. The time of arrival is determined by means of a very sensitive seismograph, in which a heavy mass is supported on a spring in such a manner that minute motions of the earth's surface in a vertical direction are detected by the small relative motion between the base of the instrument (which follows the motion of the ground) and the suspended mass. The relative motion is then magnified fifty thousand or more times and recorded on a uniformly moving photographic paper. When the earth is at rest, and before the arrival of the wave, the record takes the form of a straight line, which is immediately disturbed on the arrival of the wave. The instant of the explosion is marked on the same record by means of a wireless signal which is operated by the explosion, and a time marker, operated by a pendulum or a tuning fork, enables the time interval between the two points to be determined with accuracy.

Owing to the fact that elastic waves travel through different rocks with different velocities, they will be refracted on passing from one stratum to another of different velocity. This fact forms the basis of the seismic method of investigation and makes it possible under suitable conditions to determine the thickness of overburden, and also to reveal the structural conditions to a considerable depth. In reconnaissance surveys over large areas, it is usual to cover the area with a series of overlapping fans, so arranged that each portion of the area is shot twice in directions roughly perpendicular to each other. In more detailed surveys a profile is generally shot across the area, the length of the profile being about four or five times the depth of penetration desired. The charge necessary to furnish a record varies considerably with the length of the shot and the type of terrain. It is customary to adjust the sensitivity of the seismograph to the maximum value possible that will just eliminate "earth unrest." The amount of explosive required is then judged from this sensitivity and the type of terrain. Rocks transmit elastic waves well, and require only small charges, while wet clays and sands are poor transmitters, and with dry sand very large charges are required. In order to render the explosive more effective it is the usual practice to place the charge at the bottom of a specially prepared hole, thus reducing the amount of explosive required and eliminating the cost of filling craters produced by the explosion.

Several electrical methods have been evolved for the purpose of locating metallic ore deposits and revealing sub-surface features, and although these methods differ materially in certain respects, they are all based on the existence of outstanding differences of conductivity between the mineral bodies and the enclosing rocks. The "spontaneous polarization" method makes use of the fact that small electric currents are produced naturally by certain ore disposits and circulate continually in the vicinity of these bodies. It differs fundamentally from all other electrical methods which employ artificially generated electric currents applied to the ground either by means of electrodes or by induction. In general, when using the spontaneous polarization method, the greatest negative potentials occur above pyritic bodies, which are surrounded by equipotential lines of decreasing negative potential. The presence of the pyritic body is readily revealed by maps of equipotential lines. The method has proved successful in the location of readily oxidizable minerals, such as pyrites, metallic sulphides, anthracite, and certain carbonates.

In other electrical methods, energy is supplied to the ground either by means of metallic



GRAVITY GRADIOMETER.
Used for observing small local changes.

electrodes or inductively from suitably placed loops or coils, and the resulting electrical or electromagnetic field is carefully examined. Good conductors, such as ore bodies, produce distortions of these electrical fields. A careful critical interpretation of these distortions gives valuable indications of the location of useful mineral deposits, and may prove of assistance in the analysis of geological tectonic conditions in regions where little definite information is available. The minerals located most readily by means of electrical methods are those possessing high metallic lustre, but of these only pyrites, chalcopyrites and arsenical pyrites are to be found in large masses. Graphite and dry anthracite coal are excellent conductors and may readily be recognized. Many metallic ores such as loose iron ores, tin ores and zinc blende are very poor electrical conductors, and as a result cannot be located directly by means of the electrical methods. Certain structural problems have been solved by these methods, and examples are known in which the equipotential method has been used successfully for determining the position of faults and the strike of covered beds, while the resistivity method, which has a somewhat greater penetration, has been usually applied to determine such questions as depths and dips of hidden strata, the thickness of basalt capping and similar problems.

In all geophysical methods, the task of interpreting and making the necessary corrections to the field observations is a matter of the utmost importance, and requires a degree of skill which is only to be obtained from experience. The problem confronting the geophysicist is that of determining a disposition of strata which theoretically should give results corresponding with those already obtained in the field. It is seldom that a unique solution exists, and generally several arrangements may be found, each capable of giving the same results. From these the geologist is able to select the one most likely to accord with the true conditions.

New Treasures for the Nation.

A NUMBER of valuable acquisitions has just been made by the British Museum. The King has deposited on permanent loan a spear and necklace which were presented to him last year by Ringapat, King of the Big Nambas of North Malekula in the New Hebrides, in token of his renunciation of cannibalism and of his good will towards white men. The spear-head, which was formerly kept poisoned and wrapped in leaves, is carved in the form of a double human head, and the haft is blackened with the smoke of the chief's hut.

The Department of Manuscripts has acquired a remarkable painted vellum roll, apparently of German work and dating from the late twelfth century. The paintings depict eight scenes in the life of St. John the Baptist and may be copies of, or studies for, wall paintings. The only other roll of the kind known is also German, and is decidedly later in style. Other manuscripts acquired include a volume bearing a presentation inscription of Emma, Lady Hamilton, to Nelson, a collection of papers of the late Sir William Ashley, a large collection of transcripts of American eighteenth century historical papers, and a selection of autograph letters by Carlyle, Scott, General Gordon, and others. The late Dr. A. P. Maudslay has bequeathed many volumes from his library, and a number of books, rare pamphlets and photographic enlargements have been deposited in the library of the Ethnographical side of the Department of Ceramics and Ethnography, where they will be in convenient proximity to the remarkable Central American sculptures which Dr. Maudslay presented.

A selection of the relics of Tasian, Badarian, and other pre-dynastic Egyptian cultures, excavated in Middle Egypt, are the earliest yet discovered. The Department of Greek and Roman Antiquities has acquired three interesting late Imperial Roman ivory objects carved in relief, of which a Maenad with thyrsos, approached by a boy and a Cupid, is particularly notable.

British antiquities include the late Saxon brooch found at Pitney, near Glastonbury, which has been deposited on permanent loan, and the Anglo-Saxon antiquities discovered in the 1840's at Holme Pierrepont, near Nottingham. These were carelessly excavated and have never been properly described. Of a pair of Derby porcelain figures, a girl with a lamb and a boy with a dog, one bears underneath it a very rare feature—the incised name of the modeller or figure-repairer, Charles Bullock, hitherto unknown in this connexion.

Of the acquisitions for the Library, one of the most interesting is an unrecorded manifesto issued on behalf of the actors of Drury Lane in 1709. It is entitled "An Advertisement Concerning the Poor Actors," and contains a protest against their wages and the threat of a strike.

New Apparatus for Mine Rescue.

By T. C. Crawhall, M.Sc.
Science Museum, South Kensington.

The recent colliery explosion at Whitehaven, in which twenty-six men lost their lives, draws attention to the need for suitable rescue devices. An expert here describes the latest types of portable breathing apparatus.

ALTHOUGH death may be instantaneous as the result of a colliery explosion, the investigations of Professor J. S. Haldane have shown that about ninety per cent of the deaths resulting from such disasters have been caused by the poisonous gases formed along the path of the explosion. Of these gases one of the most dangerous is carbon monoxide, which is so insidious in its action that a person breathing it remains unwarned until dizziness is felt and the limbs fail. It is then impossible for him to escape unaided.

Coal mining has been carried on in this country for several centuries, and for almost two hundred years there have been deep mines of the type with which we are familiar to-day. But it was not until 1879 that an Englishman, H. A. Fleuss, invented the prototype of the modern portable breathing apparatus, which proved so essential in connexion with the recent disaster at Whitehaven. As early as the latter part of the eighteenth century, however, attempts had been made to evolve some form of apparatus which would enable a man to enter an irrespirable atmosphere for the purpose of rescuing colleagues. This took the form of a mouthpiece and a length of flexible pipe through which air could be drawn from some convenient source of pure air. Improvements were first of all made by fitting a valve to the mouthpiece and later by replacing this by a helmet. A very similar type is used to-day under suitable circumstances, particularly if smoke is present.

Fresh Air Supply.

If the distance from the fresh air supply is too great for the wearer to draw the air without some external aid, it is pumped to him by a simple form of bellows operated by a man in the region of pure air. The air is conveyed through the pipe to the helmet, and the exhaled gases are discharged into the surrounding atmosphere, either through the loose joint between the helmet and the wearer's shoulders or through a small valve in the top of the helmet. The helmet can be fitted with a telephonic apparatus so that the worker is in direct touch with those out of the danger zone, or he may simply have a signal horn for signalling to his attendant.

It will be realized, however, that this method of supplying air to a man working in a difficult position has very severe limitations, one of which is that the distance of the worker from a supply of pure air must not exceed about 150 feet. The flexible tube may be cut by a tub wheel or by a falling stone, and if there should be a fall of roof which completely blocks the road the man is unable to use any other means of escape, should one exist. These and other reasons make it necessary to have recourse to an entirely self-contained apparatus.

A New Equaliser.

It has already been stated that there are, in spite of these drawbacks, certain circumstances under which the hose-pipe type of equipment can be used with advantage; and this fact is borne out by the recent introduction of one or two essential improvements. These have resulted in an apparatus known as the Brigg's Equaliser, recently introduced by Dr. Henry Briggs, professor of mining at Edinburgh University and one of the greatest authorities of the present day on mine rescue work.

In this device the helmet has been replaced by a mouthpiece and nose-clip, and the wearer carries on his back a bellows-shaped bag constructed of balloon fabric mounted on strips of steel. During inspiration the bag is partially flattened and during expiration, which takes place through a special type of valve below the mouth of the wearer, the bag is again opened out, partly by the steel strips and partly by a coiled spring inside the bag. The bag is connected to the air supply pipe by a T-piece and by this means a steady flow of air is supplied to the wearer. One of the chief recommendations of the Committee appointed by the Advisory Council for Scientific and Industrial Research was that only apparatus which had been approved by the Mines Department should be permitted to be used in mines, and that these should conform to certain specified standards

this recommendation was adopted. The approved types are few in number and include two of American design. As these are very similar to those designed in this country this article will be confined to describing the British types. These designs were produced after the appointment of the Committee as, at the time of their first report, there was no apparatus in existence which would entirely conform with their recommendations.

A successful portable breathing apparatus must do more than merely allow a man to breathe in a vitiated atmosphere. It is essential that it should be so constructed as to allow him to do a reasonable amount of work and to remain in the atmosphere for a sufficent length of time. The essential requirements are, therefore, lightness, good balance and comfort, reliability, compactness, freedom of movement, absence of complications, and capability of at least two hours' service. Modern self-contained breathing apparatus consists primarily of two parts, one which absorbs the carbon dioxide in the exhaled breath and the other which makes up the deficiency of oxygen in the air in circulation. In addition there must be some form of breathing bag from which the air may be inhaled. These three items combined with the lungs form a closed circuit through which the air is continuously circulating.

MODERN BREATHING APPARATUS.

The photograph shows a miner in an underground working wearing Brigg's breathing apparatus. An important feature is the fact that it is carried entirely on the back.

The deficiency of oxygen may be provided either by compressed oxygen or by liquid air. There is a widespread and entirely erroneous idea that liquid air, which may be poured as freely as water, is a novelty. That it has a decidedly practical use will be shown later in the description of the liquid air apparatus, which is now widely used in this country.

As the disaster at Whitehaven is still fresh in one's memory, it may be well to describe the rescue apparatus which was used in this disaster first of all. This is a portable breathing apparatus of the compressed oxygen type, recently perfected by Professor Briggs, the inventor of the Equaliser already described. It is carried entirely on the man's back, a feature on which great stress is laid by its advocates. The compressed oxygen is stored at a pressure of 120 to 150 atmospheres in a steel cylinder which is fixed in a horizontal position at the lowest extremity of the equipment. The oxygen is passed through a reducing valve of special design which delivers a constant flow of two litres per minute at a pressure slightly above that of the atmosphere. Normally this quantity is more than would be required and the excess blows off automatically through a relief valve. In the event of more oxygen being required there is a by-pass which, on the simple pressure of the thumb, will allow an extra quantity of oxygen to pass into the apparatus. The by-pass may also be used to clear the apparatus of an excess of nitrogen, which may gradually accumulate.

The main valve controlling the supply of oxygen can only be operated by a special key, carried by the leader of the rescue party in order to prevent any interference with the supply. The valve is so set that the quantity of oxygen is always in excess of the requirements. The oxygen joins the main air supply in the metal pipe leading to the mouthpiece after passing through a resistance in the form of a tight pad of cotton wool, which ensures that the oxygen is thoroughly diffused. The mouthpiece is connected to the metal tube by a flexible canvas-covered rubber pipe, which is led over the man's shoulders ; in this pipe there is a non-return valve which prevents the air from circulating in the wrong direction.

The metal pipe is further connected to the breathing bag ; this is carried at the top of the back and is constructed on the bellows principle, similar to that of the Brigg's Equaliser. On the outside of the bag is a flat sheet of chemically-blackened brass which serves to protect the bag against damage and, at the same time, to radiate heat in order to keep the breathing air cool. The weight of the plate causes a slight pressure on the air in the bag and thus ensures that any leakage will be outwards to the atmosphere, so preventing the admission of the surrounding poisonous gas into the apparatus. The bag is further protected against damage, or flattening,

by the strong metal tubular frame through which the air is circulated. These tubes also assist in cooling the air by direct radiation to the atmosphere.

In earlier types of portable apparatus it was usual to employ a helmet, but this has now been entirely superseded by a type of mouthpiece. A helmet is only additional weight to be carried and the large space inside it allows carbon dioxide to accumulate, so impairing the efficiency of the equipment. The mouthpiece of the Brigg's apparatus is made of rubber and fits closely at the edges in order to prevent the leakage of poisonous gas. Below the mouthpiece is a saliva trap to prevent the saliva from finding its way into the apparatus. To ensure that the gas should not be breathed through the nose a screw-operated nose-clip is fitted.

The nose-clip and mouthpiece are held in position by attachment to a skull cap which is made of skeleton form in order that it should not be too hot for the wearer. Over the top of the cap is a piece of cane, running from front to back, which forms some protection against a blow on the head. Two rubber lugs on the inside of the mouthpiece are held between the teeth in such a way that there will be no resistance to breathing, and a shaped strip of canvas fits round the chin to prevent the jaw from being dropped so far that it is possible to breathe over or under the mouthpiece.

THE "PROTO" EQUIPMENT.
This apparatus is in widespread use. (Copyright photo by Siebe, Gorman & Co., makers of the equipment.)

After leaving the mouthpiece, the exhaled air passed through the return tube to the purifier, which is situated on the man's back below the breathing bag. This consists of two compartments into which caustic soda granules are inserted in gauze-covered receptacles. The carbon dioxide in the exhaled air, which must pass through the two compartments, is absorbed by the caustic soda and the remaining air is passed on to receive its fresh supply of oxygen. When fully charged the apparatus weighs about thirty-six pounds and can be carried with ease by a healthy man, at the same time allowing him to do a considerable amount of useful work. In many cases an electric lamp is fitted to the front of the skull cap, and this type of lamp is becoming widely used for the reason that it leaves the man's hands free for work. The battery is carried on the belt and is connected with the lamp by a flexible armoured cable. An electric lamp of some kind is essential, since there is generally insufficient oxygen present in the atmosphere to support the combustion of an oil lamp.

The other form of British "approved" apparatus using compressed oxygen is known as the Proto, and is claimed to be the direct descendant of Fleuss's apparatus of 1879. The principle on which it operates is identical with that of the Brigg's apparatus in that the wearer breathes the same air over and over again. The carbon dioxide is absorbed from it after each expiration and the requisite amount of oxygen is restored to it, but the arrangement of the component parts is very different.

In this case the steel cylinder, containing 10½ cubic feet of oxygen at 120 atmospheres pressure is the only part of the equipment which is carried on the man's back. Incidentally, it may be of interest to note that the cylinder is tested to a pressure of 3,360 lbs. per square inch in order to make sure that no accident will occur when it is in use.

The breathing bag, which is constructed of vulcanized india-rubber, is contained in an outer bag of tanned canvas and is divided into two compartments which are in communication with one another at the bottom. About 4½ lbs. of a special carbon dioxide absorbent, invented by Sir John Cadman, is contained at the bottom of the breathing bag and the exhaled air in passing from one compartment to the other must pass through this absorbent. Caustic soda stick may be used when it is not possible to obtain the special absorbent.

The absorption of the carbon dioxide generates heat and, in order that the breathing air should not become unduly warm, arrangements must be made for cooling it. In the Brigg's apparatus, this is accomplished by radiation from the plate on the back of the breathing bag and from the metal pipes conveying the air, but in the Proto apparatus it is

achieved chemically in a special cooler, which is attached to the top of the breathing bag. The cooler, which is made of copper, contains about six ounces of sodium sulphate and is connected to the inspiratory tube and to the breathing bag.

Breathing Arrangements.

The breathing circuit is extremely simple. The air passes from the mouthpiece, which is similar to that already described for the Brigg's apparatus, directly into the breathing bag through a short length of rubber tubing. Its course is then down one compartment of the bag, through the caustic soda, up the other compartment and through the air cooler into another flexible tube connected to the mouthpiece. In the flexible tubes there are mica non-return valves which ensure that the air passes in the correct direction. The make-up oxygen, which passes through a reducing valve on leaving the cylinder, is led into the top of the breathing bag, near to the cooler. The reducing valve is so adjusted as to allow a flow of not less than two litres of oxygen per minute and is fitted with an emergency by-pass, which can be brought into operation if the reducing valves should fail to operate. The action of the by-pass is to allow oxygen to pass directly into the breathing bag; and, in order to ensure that the pressure in the bag does not become too great, there is a relief valve on the top of the bag.

The apparatus, which weighs about 36 lbs., may be used for two or three hours, depending on the amount of work which is being done; and, in order that the wearer may know how long he will be able to remain in the irrespirable atmosphere, a pressure gauge is supplied. The gauge registers the pressure of the oxygen in the cylinder and has a scale on which is registered the duration of the oxygen supply. The mouthpiece is held in place by a skeleton skull cap, and a nose-clip is fitted to ensure that the wearer breathes only through the apparatus. Apart from its use in a large number of mines in this country and abroad, the Proto apparatus is used exclusively by the London and other fire brigades when working in smoke-filled buildings or in a poisonous atmosphere.

The Aerophor apparatus is probably the most interesting type of all on account of the fact that it makes use of liquid air. Considerable developments have followed recent research and experimental work. The apparatus is used exclusively in the mines of the Durham, Northumberland and Mansfield districts and the liquid air is manufactured at the rescue stations. Once the requisite plant has been installed the actual manufacture presents little difficulty, and the liquid air is stored in large metal Dewar flasks. The flasks, which were invented by the late Sir James Dewar, consist of two concentric metallic spheres. A vacuum is formed by the extraction of the air from the space between the two spheres and the flasks operate on the same principle as the Thermos flask.

It will be appreciated that this type of flask is necessary in order to prevent the passage of heat from the atmosphere to the liquid air, which evaporates at a temperature considerably below that of the atmosphere. A small-bore pipe connects the interior of the container with the atmosphere in order to prevent an excess of pressure being created in the vessel. A similar but smaller type of flask is required for transporting the liquid air to the mines, where it is poured into the breathing apparatus. The liquid air is contained in a leather-covered "pack" carried on the man's back. It is necessary to have this well insulated from the outside atmosphere in order to prevent too rapid evaporation of the air. The insulating medium is magnesite asbestos and the liquid is contained in an inner perforated nickel-silver case tightly packed with asbestos fibre. Round this is another nickel-silver case and the space between the two cases is loosely filled with asbestos wool.

The liquid air is poured through a hole in the top of the pack, into which a screwed stopper is afterwards fitted, and the steadily-evaporating air passes to the breathing bag and so to the mouthpiece of the wearer. The asbestos wool serves the purpose of absorbing the liquid air, and it does this so successfully that if the pack should be turned upside down none of the liquid will escape.

The breathing bag, carried on the chest, is circular and has a capacity of six litres. The weight of liquid air carried is about six pounds, sufficient for at least two hours' working, and the weight of the complete equipment is about the same as that of the Brigg's and Proto types.

A New Epidiascope.

A NEW epidiascope has been produced by Messrs. W. Edwards & Co., of 8a, Allendale Road, Denmark Hill, London. This instrument has been specially designed to permit maximum illumination on the screen both for opaque objects and for slides, and the open base is supported from one end only, thus allowing large books, maps and solid objects to be exhibited on the stage. The door is provided with a pointer opening and also with side flaps which provide a means of access to the object stage.

Spirit Worshippers of the South Seas.

By A. M. Hocart, M.A.

As a member of an expedition to the South Sea Islands, the author has made a close study of the little-known inhabitants of Eddystone Island. The following account of their religious beliefs is based on a recent lecture in the series delivered for the Royal Anthropological Institute on the native races of the Empire.

THE Solomon Islands are inhabited by three distinct races, of which the New Georgian people are in many ways the most interesting. It was this group which was selected for special study by the leader of the Sladen Trust Expedition, particularly the inhabitants of a small island called Eddystone. The choice proved to be a happy one, for the island had a reputation among its neighbours for magic and the cult of the gods, and we found that the reputation was deserved.

We did not know this, however, when we arrived, nor did we find it out in a day. The islanders do not readily confide their most cherished beliefs to the white man, from whom they have been accustomed to encounter ridicule. Moreover, the anthropologist's thirst for knowledge invariably engenders their suspicion. We had first to gain their confidence, to convince them that we respected their beliefs and above all to assure them that they would be rewarded if they humoured our inquisitiveness. We were very hospitable, therefore, towards those who would talk to us, and the more valuable their information the more hospitable we became. One of the natives, a noted story-teller, entertained us at great length with fairy stories in return for tobacco. At last his stock was exhausted, but not his craving for tobacco, so he decided to make sure of his continued welcome by revealing the cult of the gods which everyone had so far jealously kept from us. When the others saw that there was no longer any secrecy, they too became communicative; and this proved to be our introduction to the magic of Eddystone Island.

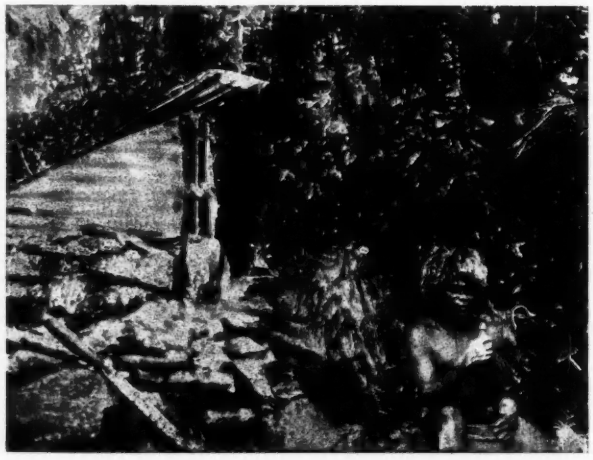
The religious cult of the islanders centres round the *tomate*, the souls of the dead. If a man is sick, the tomate are responsible. If fishing is bad, the tomate are angry. Whether the nuts are abundant or whether the enemy is defeated depends upon the tomate. When a man dies he joins the tomate and becomes more or less potent according to his success in life and his luck after death. It is highly important, therefore, to keep in touch with his soul in order to secure his assistance in the quest for food. Contact with the tomate is maintained by setting up shrines for them to dwell in. Dracaena shrubs are invariably planted upon the shrines, and the plants play an important part in the dealings with the tomate. An upright stone is erected if the body of the dead is missing—for instance, if a man has been lost at sea. The largest upright stone I saw was dedicated to a spirit which was said to appear as a light, sometimes in the form of a rainbow. This spirit carries a spear with which he causes pains in the stomach!

AN EDDYSTONE ISLANDER.
Every islander wears a string round the neck on which leaves are hung as a protection against the evil spirits.

The funeral ceremony is distinctly gruesome. The body is taken to the jungle where it is left for about a fortnight. The head is then twisted off and left to bleach in the sun. On the eighteenth day the skull is put into a "skull house," but since death has parted the soul from the body, it is not sufficient to preserve the skull; the soul must also be captured and deposited with the skull. One day I had the opportunity of witnessing the capture of a soul. Four men stood in single file outside the dead man's house, and the first held at arm's length a small ring in which was inserted a dracaena leaf. The other three also held various leaves. The first man started to revolve his arm rapidly and

then began to turn round and round himself; this continued until he fell down in a faint. The ring was then pressed to the pit of his stomach, whereupon he revived and regained his feet. Thus the soul of the dead man was recaptured. When the day comes for the skull to be taken to the skull house, the ring is placed underneath it.

There are periodical visits to the skull houses where burnt offerings are made to the tomate. We had naturally expected these expeditions to be rather solemn in character, and were much impressed by the spirit of joviality in which they were attended. I shall always recall my first attendance at a burnt offering as a very pleasant al fresco affair. We climbed the slopes of Patukio, the natives carrying baskets of nuts, to the site of an old village. When we reached the skull house the priest proceeded to cut down the vegetation which surrounded it while the islanders busied themselves in making puddings of cooked nuts and pounded yams. When the repast was prepared, the priest burned a small pudding in a fire in front of the skull house as an offering to the spirits, saying, "There is the pudding. Be effective and let us men not be ill." Then the company fell to in a spirit of cheerful contentment strangely inappropriate to the occasion.



PREPARING A BURNT OFFERING.

Seated outside one of the "skull houses," a priest is preparing a pudding of cooked nuts and pounded yams of which a burnt offering will be made to the spirits of the dead.

If our companions were at all disconcerted it was solely on account of our presence, for they were not quite sure how the spirits would like it. White men had never before attended such a ceremony—and we were so inquisitive. They therefore questioned the spirits upon this point. That is to say, the priest held up a ring, and the spirits signified their approval of our presence by settling on the ring and causing the priest's arm to revolve. It would be uncharitable to suggest that our tobacco influenced the ready acquiescence of the spirits!

Another means of soliciting the help of the deity recalls our own divining rod, only in this case it led the seeker not to water but to where a man might be surprised and killed. A very exclusive amulet was used in the form of a small cushion of plaited cane with a looped handle. It contained a special leaf which I do not recall being used in any other connexion. On arriving in enemy country, the owner extended the charm and invoked the spirits, who made his arm point in the direction of the victim. In that direction, it was believed, the victim would run, followed by the rest of the tribe. There can be no question of the sincerity of the spirit worshippers. Some tried this particular means of divination and always failed; others succeeded on some days and not others. One of our interpreters claimed that he used to be able to communicate in this way with a favourite spirit, but had since lost the power and supposed that the spirit was displeased with him.

I am not so certain of the sincerity of another man, who made the spirits communicate in whistles. On one occasion, about five weeks after the death of an islander, several of the spirits came from the land of the dead to fetch away the soul of the dead man. We were assembled in a large hut, and shortly after the lights had been put out we heard a low whistle. It was the arrival of the first spirit. The natives enquired its name, and the reply was a whistle. Spirit after spirit appeared and all communicated in a whistle. The performance was rather dull for us who could not follow the conversation. Obviously, the medium had done the whistling; he may have done so in a trance, but I think it is doubtful.

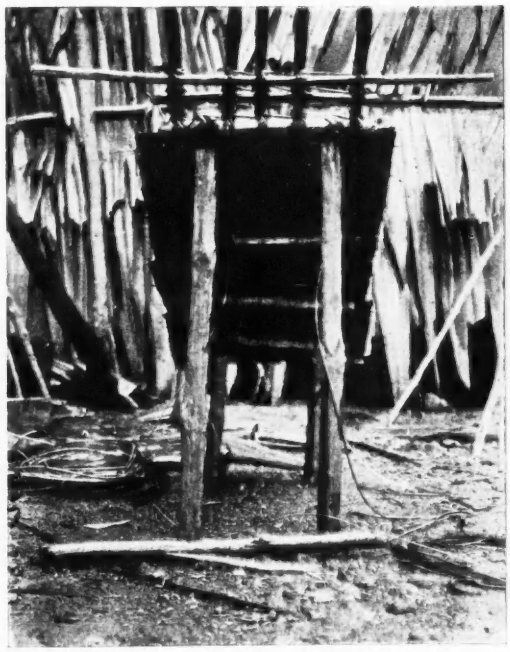
As there were many spirits in the jungle, the Eddystone islander had to be as careful to dodge them as we are in negotiating traffic. I was much amused on one occasion at the paternal solicitude with which a boy of twelve, who was guiding me through the jungle, hung leaves on my neck to protect me from the spirits of the forest. Almost every native always wore a string round the neck for the purpose of hanging leaves. As we passed through the

jungle, we were continually being warned not to tread on this or that piece of ground as it was haunted by leprous spirits, or by mad or consumptive spirits who might inflict us with their disease. Since every illness is caused by spirits, only a spirit can provide a cure, and many remarkable cures have been devised. Dizziness or epilepsy, for instance, is cured by stroking the patient from the head downwards with specified leaves. "Stroke away, cease thou," the doctor repeats. "They have given me a good fee." Curiously enough, the cure is not effective without the fee. The patient must then inhale the fumes of other leaves, after which more leaves are hung on neck and applied to his temples.

According to many anthropologists, the South Sea islanders believe that every object, living and inanimate, possesses a soul capable of thought. This supposition has not been borne out either by my own observations or by those of other explorers with whom I have discussed the subject. In Eddystone, the word for "soul" is more accurately translated as a shadow or reflection, as in water or a mirror. Anthropologists have, perhaps, been misled by the fact that souls are believed by the natives to dwell in stones and trees. But these souls are not thought to be those of the stones but the human souls which haunt them.

In Eddystone, rights of ownership are closely related to the belief in spirits. Personal property is not closely guarded, for there is much land and a sparse population. Moreover, the climate is such that everything decays rapidly and hoarding is seldom possible. If he feels thirsty, therefore, the islander simply climbs the nearest cocoanut tree to gather nuts. But the owner may be contemplating a feast, and because he cannot spare the nuts he ties in a conspicuous place the leaves appropriate to his familiar spirits. Thus he may place the leaves which are claimed to cure dizziness in a forked stick at the foot of the tree. The natives seldom fail to respect such taboos, but occasionally they are defied, when the trespasser never fails to develop the appropriate disease.

An important outcome of the doctrine of spirit worship is the practice of head-hunting. Thus, on the death of a chief or the completion of a new building, certain members of the tribe go out and kill a neighbour whose head is brought back. In the New Georgian group there is a growing aversion from taking the heads of neighbouring tribesmen, and their activities are now largely confined to hostile tribes. The practice of head-hunting is particularly repulsive to Europeans because of the unsporting way in which it is carried out. The hunters lie in wait for the captive, who is usually attacked from behind. The victim may be an old woman who has come down to the shore to gather shell fish.



AN UNFINISHED "SKULL HOUSE."

On the death of a native, the head is severed from the body, and after being left for a fortnight to bleach in the sun, it is placed in a "skull house."

It is not clear how head-hunting has arisen out of a belief in spirits, but there are three theories. It may be a type of spirit cannibalism: the shadow of the dead enemy is eaten by the shadow of the dead chief. We have no conclusive evidence of such a belief in Eddystone, but we have in Fiji, for Williams wrote "the Fijian spirits eat the souls of all whose bodies are devoured by the people." The second theory is that the spirit of the dead enemy is intended as a companion for the soul of the chief. We have definite evidence that this belief was held in Eddystone. Lastly, in the case of the completion of a new house or canoe, it is possibly believed that the spirit of the dead man acts as a guardian. Whatever the theory, head-hunting is the greatest enthusiasm of the islanders' lives, and it is difficult to know how the practice is to be suppressed. Since the war the native has been much perplexed to know why he should be hanged for taking one life while the white man is rewarded for taking twenty or thirty in war. The problem remains to be solved.

Book Reviews.

Limestones: Their Origins, Distribution, and Uses. By F. J. North, D.Sc. With a Foreword by Sir Henry Maybury. (Thos. Murby. 16s.).

(Reviewed by Professor J. W. Gregory.)

Of the common rocks in the earth's crust, limestone is of the most varied and important service to man. Its debris in the soil supports the growth of cereals and of most valuable vegetation, and the unsurpassed beauty of the flora of limestone hills. It provides one of the most attractive and easily worked of building materials, and the best of statuary marble. As the base of mortars and cements it is necessary for the construction of arches and most modern edifices. It is indispensable to industries, as the flux by which the metal is extracted from the ore in iron smelting. Limestone is largely used in most chemical industries. It is the main constituent in the metal of many roads, and natural asphalte is a bituminous variety. It is the bed-rock of many valuable ore-deposits, and is the source of much mineral oil. Limestone has also the interest of the great variety in its modes of formation; as tufa, it is deposited from springs and streams; chemical reactions that remove noxious waste organic products precipitate widespread beds of limestone on the sea floor; vast sheets of it are due to the accumulation of dead shells in lakes and the sea; huge domes of it are built up by the growth of coral reefs on a sinking sea floor. In limestone, moreover, occur the world's most famous and extensive caves.

Limestone has, therefore, many sources of interest. Dr. North's excellent monograph, which well describes its formation, distribution, economic, and artistic uses, gives an interesting and reliable account of the rock in all its varied aspects. The first part of the book summarizes the formation and nature of limestone. The bulk of the volume is devoted to a description of the limestones of the British Isles arranged in their geological sequence. It is illustrated by over two hundred well selected photographs and diagrams, and they are rendered more useful by their explanatory titles and captions. The text is also enlivened by frequent reference to the uses of the limestones, to historical incidents during their investigation, apt quotations from historical literature, and mention of interesting special cases, such as the Sunday Stone described by Buckland; it was a calcareous incrustation formed in a coal mine, and the greater thickness of every seventh white layer was due to the Sunday rest.

This part of the book gives a useful summary of British stratigraphical geology. There are, naturally, many points in this section on which the author's conclusions may be questioned. Thus he retains the Durness Limestone of the north-west of Scotland as Cambrian. Dr. North truly remarks that its fossil fauna is the same as that of some limestones in the State of New York; but no recent American authority regards that horizon as Cambrian. Salter, the palaeontologist to the English Geological Survey, correctly recognized the fossils as Ordovician; but when Olenellus was found in the rocks below the limestone it was rashly swept into the Cambrian. In reference to Olenellus, the author accepts it as found in England, but as Lapworth recognized, the Midland trilobites thus identified are really Holmia. Their retention as Olenellus confuses the evidence as to the distribution of the North Atlantic Cambrian seas. The author usefully calls attention to the evidence for the pre-Cambrian age of the statuary marble of Carrara. He adopts Bala instead of Caeradoc for the uppermost Series of the Ordovician (page 85). The attribution of the Old Red Sandstone in figure 56 to a lake or estuary, is not in accordance with the general current interpretation, which regards that formation as deposited by shifting rivers on land. As there is a rich fauna of Stromatoporoids in the Upper Cretaceous of France, that group did not die out at the end of the Devonian. The Coralline Crag was so named from the identification of its Bryozoa as corallines, which are plants, and not as corals. The Bryozoa, moreover play a larger part in the formation of limestone than would be inferred from the remark on them in the classification of the Animal Kingdom. The author refers to the stalactites on a bridge in Edinburgh as evidence of their rate of growth, which took a century to form an inch-and-a-half, and he quotes as exceptionally rapid the rate of thirty inches in a century. On some Highland railway bridges, however, they have been formed to a length of eight inches in less than sixteen years.

The third part of the book includes five chapters on limestone in relation to scenery, agriculture, and water supply, and to its economic uses; it is followed by five appendices. One of them, gives the output of British limestone in recent years, and the figures on page 412 show that the amount used as road metal has increased nearly five times between 1907 and 1927.

The book is well printed, the illustrations are well reproduced, and the work will be welcomed as a reliable and scholarly addition to British stratigraphical and economic geology.

Little America. By Richard E. Byrd. (Putnam. 12s.)

This book is the official narrative of the American expedition which spent fourteen months on the Ross Barrier in the Antarctic under the author's leadership. The expedition was remarkable in many ways: it was the first American expedition to the Antarctic for nearly a hundred years, and it employed to an unusual extent the new weapons of the explorer—the aeroplane and wireless communication.

The book follows all the best traditions of polar narratives, and although some of its excellence is due to its contrast with the Press reports of the expedition which were apt to be extravagant, it will in time be regarded as one of the major narratives of exploration of this decade. Besides being a great organizer and a bold aviator Admiral Byrd has shown himself to be a writer of talent, rarely tempted away from his plain tale but succeeding very well when he does attempt to describe scenery or to philosophize on things in general. To condense the events of nearly two years into four hundred pages is no light task, and it is therefore not surprising that we close the book feeling that we do not know the men very well. But we are persuaded that they too, for the most part, followed the traditions of polar service in hard and willing work and cheerfulness under hardship.

The expedition was by far the largest and most costly which has ever visited the Antarctic, and there is a tendency to regard the results as incommensurate with its size. Critics are apt to forget that the inclusion of aeroplanes in the equipment for polar work involves personnel which cannot be called upon for exploratory work. We have grown accustomed to expeditions taking only two classes of men, scientists and sledgers, and the scientists have usually been sledgers as well,

so that in the summer the whole expedition except a small nucleus was occupied in travel. But in this expedition, of the forty-two men in the landing party only six could be spared for an extended journey by sledge, and only four or five took part in the flights. There were, therefore, some thirty men at headquarters almost the whole of the summer. This ratio of travelling personnel to maintenance personnel will, no doubt, be improved upon in time, but the fact remains that machines require a large technical staff.

It is a feature of the expedition, of which the leader is rightly proud, that there were no casualties, although the weather was as unkind as Antarctic weather usually is. On the other hand, the student of former expeditions may consider that the precautions taken were somewhat overdone, largely because of the too easy communication by wireless. But it was doubtless the inexperience of all hands which made the leader make assurance doubly sure, and that must be accepted as the reason for sending four dog teams to relieve three men only 125 miles from the base. This instance points the moral that aeroplanes may be swift but they are not yet sure, and therefore there must be a surface personnel able to relieve an aerial party, all of which tends to make an expedition unwieldy.

The various flights, including that to the Pole and back, are graphically described, and in so far as photographs can take the place of more detailed examination they will have increased our knowledge very much. One naturally wishes that circumstances had permitted a long flight into the really unknown quadrant to the south-east of the headquarters, as we are still left in uncertainty as to the extent of the Barrier in that direction.

A chapter which will appeal to the old-time explorer is contributed by the chief of the scientific staff, Dr. Lawrence Gould, giving the events of his long journey by dog sledge to the southern end of the Barrier. The general results of their six weeks' journey should be very valuable, for no one before has ever had time to make a detailed survey of that southern fringe. The book is well but not profusely illustrated, the photographs from the air being especially good.

Bird Life in England. By JOHN KEARTON. (Philip Allan. 12*s.* 6*d.*).

The name Kearton is so closely connected with the qualities of patience and skill in bird-photography, and a faculty for observing keenly and describing vividly the things which so many bird-photographers miss, that it is no surprise to find in this new book the same traditions well maintained under another author than the familiar Richard (or Cherry). From a scientific standpoint the publishers must be counted bold in claiming this volume as "a study book for the ornithologist," and the author, who writes engagingly and unpretentiously for the layman, would hardly have put forward such an assertion: the value of the book clearly lies first in its photographs, which are distinguished by an exceptional originality and intelligence, and secondly in its readable and well-informed popular account of the birds treated.

What lifts the photographs out of the depressing ruck of normal bird pictures is not so much their technical excellence as the fact that they are taken with an eye to illustrating things. The average bird-photographer is not sufficiently tendencious. He is out purely to get good pictures, and his harvest is an endless collection of "stills" showing birds in perhaps half-a-dozen assorted attitudes at the nest and engaged in getting food or drink. That is the chief reason why the large contribution which bird-photography was once expected to make to ornithology has never materialized. Mr. Kearton shows signs of breaking away with success from this deadening stereotyped tradition. The series with which he leads off consists of fifteen pictures of a young blackbird, from the egg to the fledgling stage, all, except the last, photographed at the same time and the same distance against the same background. The result is of scientific precision and of evident general interest. The same is true of the pictures of lapwing's eggs disturbed on purpose and re-arranged by the bird, and, to some extent, of the portrait of pied woodpeckers at a drinking-place and the fine studies of a starling and a dipper. Where the author has been content with the usual pose of the bird visiting the nest he succeeds only where the subject is rare and the likeness unusually good, as with the Dartford warbler and the woodlark.

Like many observers living outside the County of London, Mr. Kearton in referring to metropolitan bird life is apt to underrate its diversity: several of the species given as still found nesting within twenty miles of Trafalgar Square—for instance, the sparrow-hawk, long-tailed tit, wood-wren, and red-backed shrike—breed or have very recently bred within the seven-mile radius, while another, the pied woodpecker, occurs much closer to the centre at Holland Park and Ken Wood.

Flights from Chaos. A Survey of Material Systems from Atoms to Galaxies. By HARLOW SHAPLEY. (McGraw-Hill. 12*s.* 6*d.*).

It was said of Sir William Herschel that he burst the barriers of heaven; it may justly be said of Professor Shapley that he has carried Herschel's work much further, and replaced his vague estimates of distances by values that can claim precision. Though he does not dwell in this book on his own contributions to our knowledge of distant systems, all who have followed the course of astronomical progress in the last decade or two will remember that his determination of the distances of the globular clusters by means of the Cepheid variable stars was the beginning of a triumphant progress which has led on to the still more distant spiral nebulae; we now say, with fair confidence, that one spiral is twenty-five million light-years away, and another seventy-five million.

The author aims throughout at method in classification; he begins with electrons and protons, while warning us that future science may carry the sub-division of matter to still smaller entities. He goes on to meteors, comets, planets, suns, systems of suns, galaxies, supergalaxies, and the whole assemblage of these, which he calls the metagalaxy. He states his belief that many of the meteors that the earth encounters have speeds exceeding the parabolic speed, which implies that they are visitors to our system from the region of the stars. If this is granted, he points out that no stars can be quite unattended; if they have no large attendants, like the planets of the solar system, they have at least swarms of meteors.

Professor Shapley has of late been giving much attention to systems of galaxies; there is a well-known group of them in Virgo, and another in Pegasus. A sketch of the latter is given; it suggests a battle between several cuttle-fishes that are squirting clouds of ink over each other, the ink being scattered starstreams that seem to have broken loose from their galaxies. Shapley makes out a good case for our own Milky Way being of a composite nature; he thinks that the local cluster round the sun,

the similar cloud in Scutum, the globular clusters, the Magellanic Clouds, are all components of an immense supergalaxy, hundreds of thousands of light-years in diameter. Pictures are given of various types of spiral nebulae, and three different methods of classifying them are explained. One of our nearest neighbours among the spirals, the Great Andromeda Nebula, has two small companions and forms a good example of a composite galaxy.

There is a chapter on the "Cosmoplasma": this term is used to denote the large amount of scattered matter and energy that there must be in the spaces lying between the galaxies; there is the radiation of countless stars, besides the matter expelled from eruptions of stars or from the tails of comets; there are doubtless a number of stray stars in these regions, that have moved too fast to be controlled by the gravitation of their galaxy. The author notes that this cosmoplasma may play an important part in the formation of future star-systems, and that its total mass may perhaps exceed that of all the galaxies.

It will be seen that the book is a comprehensive one, and written by a master of the subject. It would, however, be greatly improved by the addition of an index; it abounds in information, but it is not easy to find the particular item desired.

The Dynamic Universe. By JAMES MACKAYE. (Scribners. 10*s.* 6*d.*).

This is one of the most interesting and entertaining books we have read for a long time. The reviewer confesses to a long-standing and heretical feeling of hope that some day someone would come along and shatter the relativity theory. It is clear that the author has no such intention in the present book, but there is no doubt that he is an able, learned and severe critic. His thesis, in this work, is that relativity is a metaphysical and mathematical plaything of supreme plausibility; but that it has no value as a physical explanation of human experience.

To the "verbalistic virus" (page 106) of relativity he opposes a very well-reasoned "radiation theory" which certainly at first reading conveys more homely comfort to the physicist than the undoubtedly unsatisfactory physical conceptions involved in the acceptance of Relativity. The author points out with undeniable truth that "capacity to handle symbols is one thing and understanding a non-understandable, like a red odour, an onion-flavoured sound, an octagonal shaped time, or a cylindrically-curved space-time, is another." He says that it is not the physicists but the metaphysicians who most easily understand Einstein: "They have known all along that space-time had a curvature." On the other hand, Mr. Mackaye presents us with the same old ether which in the past has been the cause of so much scientific heart-burning. He sees no reason why we should not accept this ether, but he offers us no satisfactory explanation of the many difficulties involved.

As a trenchant criticism of Relativity the book is above all entertaining. As to the validity of the author's well-reasoned argument the evidence is insufficient; but it is not without strong physical support. A further extract from the book (page 177) is a sample of the pleasant humour employed by the author in his shrewd impeachment: "We learn also that their or its 'curvature' (space-time) represents gravitation, and if profundity is proportional to unintelligibility, as is popularly assumed, we must agree with Eddington that a profound change has come over space and time since they became curved, as profound as if they had become intoxicated." Although the book is entertaining it is not elementary. To appreciate it the reader must have a sound knowledge of physics and a reasonably close acquaintance with relativity literature. The conventional and well-equipped reader will probably start the book with a compassionate smile, but he will become seriously intrigued before the end.

Early Man in North-East Yorkshire. By FRANK ELGEE. (Published by the Author at Shirley House, Commendale, York. 25*s.* 9*d.*, post free.)

Intensive research in a limited area which he knows well has enabled the author to make a really valuable contribution to archaeology. Mr. Elgee, who is the curator of the Dorman Museum at Middlesborough, has not merely done much original work on the prehistoric barrows, encampments, and forts of the district, but has also been at pains to collate the many finds made by earlier workers in the field. Thus this handsome and well illustrated volume presents, in text and pictures, virtually all that is at present known of the successive races who inhabited the coast, the wolds and the moors before the Romans came. The maps, showing the distribution of stone axes, long barrows, scrapers, urns, and other relics that afford precious indications of racial characteristics, are extremely valuable. From these it is evident that the Bronze Age was far advanced before men chose to dwell on the inhospitable moors.

The author infers that these folk—who cremated their dead and placed the ashes in urns—were driven from the fertile valleys by invaders who were stronger and richer than they. The newcomers had fine bronze weapons and imported gold—perhaps from Ireland. They, in turn, were overcome by an iron-using people from the Continent. Mr. Elgee's theory that the Brigantes of the West Riding in Agricola's time were descended from the invaders of the late Bronze Age, while the Parisii of East Yorkshire at that date were the early iron-users, is of course an ingenious hypothesis and no more. The evidence available does not yet bridge the gulf between the prehistoric and the historic. Continued research on these lines will doubtless solve the mystery. Meanwhile, this book will be welcomed by serious students of prehistory. It lays a sound foundation for further work in Mr. Elgee's own district, and sets a model for workers elsewhere in England.

The Story of Surnames. By W. D. BOWMAN. (Routledge. 7*s.* 6*d.*).

The study of English surnames is a fascinating subject. It rewards its votaries by many curious lights on the racial composition, occupations, social organization and even character of the English people, especially in the Middle Ages. It is surprising that literature on the subject is relatively scanty. This little book, although popular, is thoroughly in accord with scientific principles of investigation and is an excellent introduction to a subject which has a wide appeal once certain fundamentals have been mastered. Local names, address names, and patronymics are already familiar as the source of surnames; but in the chapter devoted to those derived from nick-names some curious and surprising derivations appear. As the author points out, some of them are obviously tinctured with malice, and among those he quotes are many which are more pointed than polite.

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